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Sixtieth Annual Report of the Director

Volume XXXVII January, 1949 Number 1

Cover: Main Gate of the Garden from the outside. Photograph by Ladislaus Cutak.

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Missouri Botanical Garden Bulletin

Vol. XXXVII JANUARY, 1949 No. 1

SIXTIETH ANNUAL REPORT OF THE DIRECTOR

To the Board of Trustees:

The Director of the Garden has the honor to submit his report for the year ending December 31, 1948:

THE HERBARIUM

The year 1948 has brought more important changes to the herbarium and its administration than in any other single department. On January 1, Dr. J. M. Greenman retired as Curator and his place was taken by his former student, Dr. R. E. Woodson, Jr. Dr. George B. Van Schaack, of Washington University, had previously been appointed Honorary Curator of Grasses, and Dr. R. M. Tryon was appointed Assistant Curator on April 1. Dr. Julian A. Steyermark, of the Chicago Natural History Museum, became an Honorary Research Associate in February.

Dr. Greenman joined the staff of the Missouri Botanical Garden in 1913. During the thirty-five years of his curatorship he has seen the herbarium more than doubled in size, and under his inspiring leadership it has become one of the world's leading centers for instruction in taxonomic botany. It is appropriate that as Curator Emeritus he will continue to work in the herbarium and return to the research in which he was formerly engaged.

For several years prior to 1948 the herbarium had become so crowded that the insertion of recently acquired specimens was no longer possible. These had to be stored in cardboard cartons where they were unavailable for study. The steel herbarium cases purchased during the current year have done much to alleviate the congestion. After the installation of the new cases a re-distribution of the entire herbarium became necessary. This was accomplished within a month by Dr. Woodson and Dr. Tryon assisted by two undergraduates from Washington University. As a result of the shift it became apparent that the additional space gained by the new cases was somewhat less than 20 per cent. This is now being augmented to some extent by the removal of duplicates which will be used for exchange with other

herbaria. Coincidental to the shifting of the herbarium and the removal of discards and duplicates the herbarium staff has undertaken a special treatment of type specimens similar to that now practiced by the Royal Botanic Gardens, Kew, and the British Museum in England. These types are not withdrawn from the general herbarium, as is done at some other institutions, but are designated by special labels and enclosed within special red-margined folders which not only offer additional protection to the specimens, but makes them easily recognized should there be any occasion to withdraw any or all of them.

The herbarium of the Missouri Botanical Garden is very rich in types. How many there may actually be no one can tell since thus far the skill necessary for their recognition has not been available. It will require several years to complete the work even under most favorable circumstances. During the year 5,687 specimens were accessioned by the herbarium, and 14,752 specimens were mounted and stamped, bringing the estimated total of specimens to 1,463,423 sheets. The mounting of the plants was done by Miss Violet Bauer, who has served in this capacity for a number of years.

The accessions of an herbarium are obtained through purchase, exchange, field work, and gifts. It is the present policy to limit purchases only from special localities, expending the funds previously available for this purpose for field work. No purchases of herbarium specimens were made during 1948, consequently it was possible to send two graduate students, Fred G. Meyer and David J. Rogers, to a little-frequented district of the Mexican states of Tamaulipas and Nuevo Leon, where they were able to obtain a splendid lot of material. The plants collected will be identified and distributed during the coming year, as will the last set of Panamanian plants collected by Paul H. Allen in 1946-47.

During the current year 4,718 herbarium specimens were received in exchange with various institutions; 6,281 were sent out from here; and 969 specimens were received as gifts. Specimens obtained through direct field work are invaluable in maintaining exchange relations with various herbaria throughout the world. During 1948 additional numbers of herbarium specimens for prospective exchange were obtained by the salvaging of over 20,000 unmounted specimens which had been in storage. Mimeographed inventories of the duplicate material which the Garden now has for exchange have been dispatched to the major European, African, and Australian herbaria and have elicited keen interest. One reason for the existence of any herbarium is to provide material for botanical research including the accurate determination of specimens. For this purpose no one herbarium is self-sufficient, and it is its privilege and its duty to lend as well as borrow from other herbaria. During the year the herbarium of the Missouri Botanical Garden

borrowed 5,859 specimens for the sake of research undertaken by its staff and students. In the same period 4,176 specimens were lent to fifteen institutions of the United States and three abroad. Since upon their return the specimens bear the annotations of the authorities who have studied them their value is increased accordingly.

In addition to the physical changes the year has seen important taxonomic problems either inaugurated or completed. Dr. Greenman has been able to resume his study of the Tropical American species of the genus Senecio, while Dr. Dodge has continued his research principally on the lichens. Dr. Woodson continued his studies on various minor topics of the families Apocynaceae and Asclepiadaceae. Dr. Tryon has been concerned with his studies on the ferns, particularly the genus Woodsia. Dr. Schery has occupied his research time with studies of the Leguminosae for the "Flora of Panama." Dr. Van Schaack continued his work with the grasses, and Dr. Steyermark made definite advances in his investigation of the flora of the Ozarks.

Numerous investigators from other institutions visited the herbarium during the year and are listed elsewhere. Dr. Lloyd H. Shinners, of Southern Methodist University, spent six weeks during mid-summer assisting in the reorganization of the herbarium, particularly the Leguminosae.

MAINTENANCE OF CITY GARDEN

The average visitor to the Garden is interested in trees, shrubs, and blooming plants, giving little thought to the vast maintenance program involved in the physical structure. Greenhouses, rest-rooms, offices, residences, the heating plant, not to mention such items as water-mains, drains, sewers, and fences, require almost constant attention. With the shortage of both labor and supplies that previously existed, work of this character fell behind, and it has only been during the past year that necessary repairs and replacements could be made. Labor usually available for gardening had to be called upon to assist in the accumulated work. Some of the major items are herewith enumerated.

The entire basement of the Administration Building was sprayed with water paint and the south end enclosed to make a room for the use of graduate students. This included the building of tables, shelves, cases, etc. A small room was repainted and fitted for laboratory use. Space previously used for storage was made available for an extension of the library. The reception room was repainted, cases rearranged, and the old Henry Shaw wash-basin was removed. The herbarium on the second and third floors called for a major rearrangement to make space for the additional new cases. Partitions of both wood and wire were removed, radiators eliminated, and doors

changed. The northeast room on the top floor of the herbarium was redecorated. A new parking lot south of the Administration Building was built. Minor repairs in conjunction with the above work required over 900 hours of garden labor. The lighting system in both the herbarium and library which had always been inadequate was completely overhauled. This involved the addition of many new fluorescent fixtures in order to serve properly all the cases and shelves.

The residence formerly occupied by the engineer was entirely redecorated, including extensive plastering. Hardwood floors were refinished, and the floors on the second floor repainted. The old electric wiring and connections were replaced and the exterior repainted. Necessary repairs to roofs, including copper flashing and downspouts, were made at the Director's residence and on the Administration Building. A large new window was installed on the east wall of the superintendent's residence.

The asphalt shingles on the curved section of the Main Conservatory roof have long needed replacing, but only the roof of the Palm House could be supplied with new shingles this year. All the service sheds, the potting shed, and garage were reroofed with tar paper. The small packing and shipping room in the orchid shed had outgrown its usefulness so a new shipping room was converted from the old storage shed. This is now furnished with tables, shelves, cases, etc., and a refrigerator was built to be used not only for orchids but for storing water-lily tubers and for the stratification of seeds. Three old slate benches in the orchid range were replaced with permanent concrete ones, and many of the benches throughout the various houses were repaired. Top ventilators were supplied where needed and a new wooden base installed in the propagating house. A shed for storing flower pots was built north of the soil sheds, the old flower-pot shed being enlarged to provide for storage of equipment. Shadow boxes, partitions, trellises, and various structures used in the floral displays were built, and extensive repairs and construction work were done in the growing houses, including new concrete benches, pipe supports, and ventilators.

During the last several years galvanized pipe could not be obtained and emergency clamps had to be used throughout all the greenhouses to control leaks. With pipe again available, extensive replacements were made, including 1,500 feet in the Aroid House, 2,000 feet in the Citrus House, 4,500 feet in the Cactus House, 1,400 feet in the private growing houses, and over 1,000 feet in greenhouse roof supports and water-lily tanks, making a total of about 11,000 feet of pipe. New valves and unions were supplied when necessary.

Much reglazing, some of which had been too long neglected, was attended to, amounting to over 20,000 square feet of greenhouse roof glass.

On the Main Greenhouse range the interior of the east and west vestibules, the south sides up to the roof glass of the Coffee and Desert House, the west sides of the Cycad House, of the Palm House, and of the Economic House, and the north side of the Cactus House were all repainted. The south pit house in the old orchid range was reglazed and repainted. All the wooden garden benches, together with the drinking fountains and permanent outside benches, were repainted and repaired, and the offices at the Main Entrance were redecorated. A major item of replacement was the Rose Garden trellises which had to be entirely rebuilt.

Routine maintenance during the year included removing 27 dead trees and hauling 375 truck loads of leaves and brush. The trucks made 139 trips to and from the Arboretum at Gray Summit hauling all sorts of supplies as well as orchid flowers and plants. Miscellaneous hauling included innumerable loads of soil, rock, gravel, and rubbish to the outside dump. The effect of the tornado and the hail storm in September, 1946, is still very much in evidence, and a considerable amount of dead wood from trees and shrubs had to be removed during the year. Much of the Garden labor was expended on such items as edging of walks and shrubbery beds, insect and weed control, cutting of lawns, weeding and cultivating shrubbery and flower beds, pruning privet hedges and innumerable others all necessary to keep the appearance of the Garden presentable. A snow storm not only necessitates clearing the walks within the Garden, but also the sidewalks bounding the Garden on Alfred, Magnolia, Tower Grove, and Shaw avenues. Even the picking up of waste paper, peanut shells, and popcorn requires an amount of labor which it would seem might be put to better use.

Keeping the plants correctly labeled and a record of their history is a continuous responsibility. Two hundred special tree labels were placed in the Main Garden during the summer; in addition 805 display labels were handwritten and 5,143 were stamped by machine. About 5,000 pot labels, used only for a short time, are written by hand every year.

Contracted maintenance during 1948.—New equipment purchased during the year and maintenance work for which outside labor was contracted include the following:

Repairing the Alfred Avenue sewer which has been periodically flooded.

New installations in the Power House.

Tuckpointing and repairing cap of smoke stack of Power House.

Installing a new oil burner at Main Entrance.

Construction of a new sewer in tunnel from south end of Floral Display House to pool west of Main Conservatory, to control flooding during storms.

Resurfacing floors and passageway of Experimental Greenhouse.

Rebuilding ceiling and bracing side walls in south end of Museum Building.

Purchase of new station-wagon and new panel truck for Arboretum and City Garden use.

Installation of fluorescent lighting in herbarium, library, and seminar room.

Completion of elevator in Administration Building.

Storm damage.—The north end of the pergola in the Italian Garden was wrecked by the wind storm of December 5, the velocity of which was officially recorded as 40–45 miles an hour with an occasional 60-mile gust. The section remaining is unsafe, and the entire pergola will have to be redesigned and rebuilt.

The maintenance of the City Garden is under the direction of Mr. G. H. Pring.

Pergola in Italian Garden after storm of December 5

MAIN CONSERVATORIES AND EXOTIC RANGES

For the past six or seven years no large-scale pruning had been carried on in the Economic House, and as a result most of the tall trees cast so much shade that a trip through the greenhouse was like walking through a dark forest. Consequently it was decided to apply the ax to some of the oldest trees that had outlived their usefulness. Two full days were consumed in carrying out the project and five truck-loads of brush were taken out. The following trees were cut down to the ground or greatly reduced in stature: *Artocarpus integrifolius* (Jak Fruit), *Cassia javanica* (Senna), *Dipholis*

salicifolia (Bustic Tree), *Ficus benghalensis* (Banyan Tree), *Ficus Benjamina* (Willow Fig), *Ficus villosa* (Shaggy Fig), *Harpephyllum caffrum* (Kaffir Plum), *Parkia Roxburghii* (African Locust), *Peltophorum ferrugineum* (Braziletto Wood), *Phytolacca dioica* (Pokeberry), *Pithecolobium dulce* (Manilla Tamarind), *Samanea arboreum* (Wild Tamarind), *Spondias lutea* (Golden Apple), and *Sterculia alata* (Buddha's Coconut). Several new seedling plants were added to the collection, among them the most notable being *Pandanus utilis* (Screw-pine), *Brachychiton rupestris* (Bottle Tree), and *Crescentia cujete* (Calabash Tree). A truckload of leaf-mold was scattered on the beds during March.

In the Banana-Coffee House, where the prominent plants are very heavy feeders, manure was again generously applied, and a good crop of fruit was assured. The tall double-flowering Hibiscus was hardly without a bloom during the entire year and always evoked favorable comment from the visitors. At times, the whole shrub was enveloped by dark pink flowers, particularly during the late summer and early fall months. The rampant climber, *Agdestis clematidea*, had to be trimmed all the way down to the exposed tubers. This tropical American vine, springing from a grotesque aggregation of woody tubers, exudes a most disagreeable odor from the stems and foliage when bruised, but a delicious fragrance from its large clusters of greenish white blossoms.

Leaf-mold and manure in generous quantities were distributed on the beds of the Fern-Cycad House, and some of the beds were replanted with fresh ferns. Several clumps of the Umbrella Plant, *Cyperus alternifolius*, which had sprung up voluntarily from an original planting around the waterfall pool in various parts of the room, had to be removed. The Fruit Salad Vine, *Monstera deliciosa*, required severe pruning as did many of the old cycads.

Heavy pruning, too, was carried out in the Palm Jungle—the tall Livistonas, Phoenix, Sabals and Washingtonias requiring most attention. The Washingtonias or Weeping Palms gave the most trouble as their dried leaves are the toughest of our palms to cut. No wonder that the dried leaves persist so long—ten to twenty-five years—on the trees in nature! It is the only palm that produces a skirt of leaves around its trunk, a kind of protective device against the drying winds of the desert. The last of the potted Fish-tail Palms (Caryota) was set out. Caryotas are fairly fast-growing species and already about a dozen are on display. They are natives of Malaysia where the fruits are utilized for making sugar, vinegar and alcoholic beverages. Additional aroids, particularly Dieffenbachias and Philodendrons, were set out and more space cleared for other low-growing herbs. An attempt to grow African Violets (Saintpaulia) in permanent beds has so far proved

successful. These stemless hairy perennials are, without a doubt, one of the choicest of blue-flowering plants and in the past few years have attracted much attention. The one small bed of mixed African Violets has been in constant flower since set out several months ago, and a further attempt will be made to enlarge the planting of them during 1949.

The renovation of the Cactus House has continued, the House having been nearly wholly replanted. Several clusters of *Yucca aloifolia* were removed and available space filled with the many xeric plants which had been collected by Ladislaus Cutak in Mexico during the winter season of 1947. These included cacti, bromels, slipper spurges, magueys, and stonecrop plants. The cactus collection was further enhanced when Messrs. Meyer and Rogers, graduate students at the Garden, brought home many living specimens of Astrophytum, Ariocarpus, Mammillaria, Neolloydia and Obregonia from their three-months exploration of the Jamauve Valley in Tamaulipas, Mexico. The Pirtle Cactus Garden in Edinburg, Texas, with whom a mutual exchange has been carried on since 1933, sent specimen cuts of some 35 species of various Cerei which were not as yet represented in our collection. Among them were *Stetsonia coryne*, one of the most striking cacti of South America, with extremely long spines; *Lophocereus Schottii monstrosus*, an oddity of the cactus world which resembles a sculptured totem pole; *Lemaireocereus Thurberi*, a very ornamental slow-growing Mexican species; and *Arthrocereus Rondonianus*, a branching and creeping dwarf with slightly pungent, honey-yellow spines. The well-known plant explorer, Mulford B. Foster of Orlando, Florida, sent a small cutting of *Strophocactus Wittii*, from the swamp forests of the Amazon. This peculiar cactus with flat, leaf-like stems closely sticks to and twines around the trunks and branches of trees and is very interesting because it is the "missing link" between the genera *Epiphyllum* and *Cereus*. As far as we know it is one of the rarest cacti in collections and at present, we are unaware whether it is grown elsewhere in the States.

In the South African House the Sansevierias again put on a good display. The flowers began unfurling at eventide and stayed open until 7 or 8 o'clock in the morning, all the while emitting a sweet odor like that of hyacinths. Several tree-like Aloes bloomed for the first time, the most showy being *Aloe supralaevis* and *A. Thraskii*, both about 6 feet tall. Other profuse bloomers were *Kleinia fulgens*, *Kalanchoe laciniata*, in addition to a host of Aloes and a number of Hoyas. *Hoya carnosa*, the Wax Plant, produced 26 umbels of gem-like bloom in August. The Haworthia collection was increased by 103 species and varieties from the Pirtle Garden of Edinburg, Texas, which has one of the largest collections of these plants in America. Haworthias are mostly stemless or short-stemmed succulents which have become great favorites in recent years. They are sometimes referred to as the "darlings of the cultivated succulents."

In the Exotic Ranges the usual routine work was carried on. All the plants in the Plant Curiosity House were repotted in fresh soil and all the orchids and most of the bromels in the propagating houses received the same treatment except that osmundine was used as potting medium instead of soil. The propagation of many exotics for replacements in the display houses was made on a large scale. Plants receiving this attention were several species of the showy Dieffenbachia, Schismatoglottis, Aglaonema, Scindapsus, Eranthemum, Polyscias, and Hibiscus.

As usual, cuttings, seeds and plants were sent to institutions and specialists working on research problems of particular groups.

Mr. Ladislaus Cutak is in charge of the Main Conservatories, including Cacti and Succulents.

OUTDOOR GARDENS

Weather conditions were more favorable for gardening operations in 1948 than in recent years. Rainfall was fairly evenly distributed and only in late summer was it necessary to resort to artificial watering. When newly planted trees, shrubs, and bedding plants receive abundant moisture during the first half of the summer they grow vigorously and become well established, but if they must be frequently watered soon after planting to be kept alive they do not grow well.

Tulips were the first major attraction of the season in the main plaza, Linnean Garden, and Spring Garden. Bedding plants followed the tulips in the Main Garden, and perennials, annuals and hardy chrysanthemums provided a succession of flowers in the Linnean and Spring gardens.

The roses were fine in May, June, and again in August. Much as the frequent showers benefited all plants, they did bring about an increase in black spot, one of the most troublesome diseases of the rose. This necessitated additional work in spraying and dusting, which amounted to thirteen treatments this year.

The Iris and Peony Garden south of the Old Residence had a good season this year. Four beds were replanted and twenty-four new varieties of iris were purchased.

This year the Economic Garden was again planted to farm and fiber crops. Small plots of cotton, tobacco, cowpeas, soybeans, castor-beans, sugar-cane and others always arouse the interest of visitors.

The Italian, or Formal Garden, receives much favorable comment, but it also requires a great deal of work to be kept in condition. Each May 10,000 bedding plants are set out and then follows the weekly round of weeding, cultivating, watering, and cutting and edging the sod borders. This year the more than 3,000 feet of privet hedge was trimmed seven times, making

a rather startling figure of clipping—more than four miles of hedge in one year in one garden.

No important changes were made in the shrubbery beds, but the following trees and shrubs were planted in various parts of the garden: 12 azaleas, 14 flowering crabapples, 12 horsechestnuts, 30 junipers, 9 lilacs, 20 magnolias, 2 oaks, 9 double-flowering peaches, 3 prunus, 14 species and varieties of shrubs, and 22 varieties of camellias for the Linnean House.

The oldest Pin Oak near the Floral Display House was removed in April. In recent years this tree had so deteriorated that it no longer served any useful purpose.

FLORAL DISPLAYS

The flower-show schedule is maintained each year with clock-like regularity. The general public is not aware of the amount of work involved in growing the plants for these shows. All the small-flowered chrysanthemums are grown in nursery rows during the summer and are brought indoors in the fall. Weeding, pinching, watering, and spraying for insects are the necessary tasks in the field, while in mid-September the greater part of a week must be devoted to digging, carting, potting, and placing these chrysanthemums on the greenhouse benches. All available space in twelve growing houses, consisting of 19,000 square feet of glass, is filled for eight weeks until the chrysanthemum show is staged.

A great deal of thought, ingenuity, and resourcefulness goes into the plan of each flower show. The location of the walks to accommodate several thousand visitors on a Sunday afternoon is a major consideration; the hanging-basket chrysanthemums must be hung so that they do not drip on flowers below; all beds must be arranged to facilitate watering the plants; backgrounds must be designed and constructed; palms too heavy to lift must be rolled on pipes; the floor area of 4,000 square feet is entirely cleared and scrubbed six times a year; every flowering plant is grown in a pot and must be carried, carted, or trucked to the display house.

In early January the poinsettia display was rearranged, buddleias and white and yellow Garza Supreme Chrysanthemums being added. An entirely new setting was built for the orchid show, which continued from February 1st to the 22nd. A large circular garden of azaleas was assembled in the Kiel Auditorium for the Greater St. Louis Flower and Garden Show, March 9–14. The Easter display opened March 21, with a major showing of Croft Lilies. Successive changes were then made at weekly intervals during April and early May. A large number of plants were sent to Christ Church Cathedral for the annual flower sermon preached April 11. The iris section of the St. Louis Horticultural Society held an iris show in the Floral Display

House on May 15 and 16. Hydrangeas and pelargoniums formed the flower display from May 16 to 30. During June, July, and August the summer show contained caladiums, fuchsias, begonias, and delphiniums. All caladiums and foliage plants were removed in late September to ready the flower house for the dahlia show of the Greater St. Louis Dahlia Society which was held October 2 and 3. The Veiled Prophet Queen's bouquet was on view October 7 and the Henry Shaw Cactus Society held its show October 9–10. Chrysanthemums were displayed from November 7 to December 5, and then the poinsettias completed the flower-show schedule of 1948.

The outdoor collections, together with the growing and arranging of the floral displays, is under the direction of Mr. Paul A. Kohl, Floriculturist.

THE ARBORETUM

Although more than the usual preparations had been made in anticipation of a dry summer, the past year was better than normal from the standpoint of "growing" weather. The usual summer drought was not too severe nor long-lasting and the month of November was the second wettest on record. On the whole, plantings have not suffered and the seasons have been such that more than the usual amount of planting could be done. In the fall 1,929 plants were moved to permanent locations; this included 374 boxwood needed to replace those killed during the very unfavorable weather of late spring. In addition, 844 White Pines and 265 White Oaks were moved from the nurseries. Many of these trees had been obtained as "lining-out" stock during the past five to seven years and were grown for eventual use along the north boundary. Some of the conifers had become so large that the dragline was used as a crane to lift and load the balled specimens and to place them in their permanent locations. Many of the large deciduous trees were dug from the nursery rows with the 13-foot blade of the Motor Grader. Thus two machines ordinarily used in heavy earth moving and construction jobs were given a chance to demonstrate their ability to reduce the hard and laborious work associated with extensive nursery operations. Comprehensive collections of herbaceous seeds and plants were made with the intention of growing them for game cover as well as for the native wild flower display, since most of them could be included in the list of plants unable to compete with civilization. Many of the White Pines and White Oaks were included in the planting along the Old Wire Road (the north boundary and now an unimportant road to Pacific, Mo.). Before the set-back windbreak of deciduous and coniferous trees could be made a great deal of grading had to be done.

As originally planned, space was to be left between the planting belt and the county road as a firebreak which would be seeded to blue grass and kept

mowed. To accomplish this 3,735 cubic yards of soil were loaded by dragline and trucked to near-by ditches before a suitable slope for the operation of a mower could be obtained. This $1\frac{1}{4}$-mile planting was completed this fall after which the banks were seeded and mulched to prevent erosion. Only one more thing is necessary—a cattle-tight fence which will also serve as a barrier to trespassers.

At the present time there are 13.52 miles of roads and trails in the Arboretum—far too much for maintenance by the old pull-type grader in use since 1926. With delivery of a new Diesel-powered Motor Grader in September it was possible to grade and reshape all the roads. This initial work required 166 hours. After shaping, 2,965 cubic yards of gravel were dug by dragline from the river bar, hauled, and spread on the roads. With subsequent rolling the roads were in good condition for the first time in several years.

On May 1, about 11:10 P. M., a tornado ripped through part of our wooded section, beginning at the west line where it cleared a path 375 feet wide and touching the ground again at the East Bridge where it followed the creek for several hundred yards. It required 414 man hours to open the main roads to traffic, but nothing else was done to these large trees until December when work started on cutting them to saw-mill size for lumber. Many of these large trees were nearly 200 years old and cannot be replaced in less time.

During the winter a beginning was made on making and placing the White Ash signboards which when assembled would tell something of the activity, the plans, and the name of specified areas in the Arboretum. A signboard with deeply carved lettering was erected at the West Bridge stating that the Brush Creek watershed has been used as a flood-control laboratory. Another was placed near the road at Crawfish Flat calling attention to the peculiarities of this site and the soil. It is planned to add more of these informal bulletin boards to keep the visitors posted on the development of the Arboretum.

Two new International dump trucks purchased to replace the 1935 model Fords have been driven almost 12,000 miles during the year. The new trucks have two speed axles and haul 5 cubic yards of gravel and soil; the consumption of gasoline varies from .862 to 1.6 gallons per hour of operation, and from 4.12 to 10.1 miles per gallon of gasoline. The dragline which will be used over 500 hours during the year can be operated on .49 gallons of Diesel fuel per hour. The Motor Grader has been operated over 200 hours since September and appears to use about .8 gallons per hour.

The usual farming operations were carried on, but in this connection it is interesting to report that since 1941, when a wheat, red clover, corn and

soybean rotation was started, the production per acre has doubled. At one time the pasture would not carry 12 cows; now 48 Aberdeen-Angus can be carried on the same acreage. One new hybrid white corn on production test yielded 100 bushels per acre, and the average exclusive of unfertilized check strips exceeds 70 bushels of yellow hybrid corn. About 71 tons of alfalfa and red clover hay were put up as winter feed for the beef cattle in addition to the 80 tons of corn used as silage.

The routine operations such as mowing and brush-cutting continue to use an appreciable amount of man hours. The shredding and hauling of manure and compost and the gathering and spreading of mulching material are all routine tasks requiring a large part of the labor available. The tank truck was used to haul 13,000 gallons of sludge used as fertilizer and an additional 22,000 gallons of water for irrigation.

A new concrete and stone bridge was completed at the Pinetum Lake spillway; the old wooden bridge which had undergone repairs year after year finally reached the point where it was no longer safe for heavy vehicles. Two stone walls were added to lengthen the flume and direct the water over the first of three masonry dams constructed in the outlet some years ago. This will permit the back-filling and planting of this area which seems to be especially attractive to visitors armed with a camera.

The Nursery contains 11,789 plants of 232 species and varieties.

Use of the Arboretum by the Public.—During the past several years since the Arboretum has been open to the public it has been visited and "used" by many organizations as well as individuals. Among them have been garden clubs with a general interest in all the trees and flowers and usually with some members interested in specific plant families. Service clubs have held meetings at the Arboretum, and while not nearly so interested in particular plantings as the gardeners, many of the members have had a keen interest in the over-all picture of "land use." Both Girl Scout and Boy Scout troops have carried on part of their merit-badge work while on a visit; some selected scouters have worked, camped, or carried out other projects while within the area. Church organizations regularly meet at the Trail House with no other idea than to have a meeting outdoors in a setting unlike that of any hall. Sportsmen's organizations, groups interested in roadside beautification and development, high-school biology classes, grade-school conservationists, university botany classes, university faculty picnics, the Audubon Society, and even companies of volunteer firemen have discovered many activities, operations, and portions of the development program that held much more than a passing interest for them.

Certain groups have met annually for five or more years. Others meet sporadically, and many plan the meeting and write for reservations a year in advance. Some, especially the scout groups, arrive on short notice whenever they can arrange for transportation. About eighteen reservations have been made for the coming year. Most visitors arrive in private cars, but the chartering of busses is becoming more popular each year.

On the 1,674 acres within the Arboretum, there is a plant or an activity, a study or an experiment, which appeals to some one in every group. Those interested in wild flowers have an opportunity during several weeks of spring, and again in fall, to walk the trails and renew acquaintance with these vanishing plants. The specialist, of course, can find vegetation of absorbing interest at any time of the growing year. Gardeners interested in horticultural plantings have the whole year, but especially the ten weeks starting in mid-February, to observe acres and acres of narcissus, and to study and compare the more than sixty varieties being naturalized. On or about April 20th the crabapples produce a spectacular display. The conservation-minded are always intrigued by the story of the Brush Creek watershed, which is one of the few, if not the only, stream-controlled laboratory in the state. Audubon Society walks permit the compilation of lists of birds observed, and generally a few uncommon birds are encountered.

Many of the groups during the past several years have had a guide from the Arboretum staff. While there is no regular guide service, if arrangements are made long enough in advance it is usually possible to accommodate a group. Meetings may be prefaced with a talk, or there can be a lengthy discussion with a short field trip. Frequently the speaker has been surprised and delighted at the interest shown in some phase of the developmental work which he had not considered a highlight of the Arboretum. The role of the Aberdeen-Angus herd in the maintenance of blue grass is one such item. Of course, the conservationists and the sportsmen are interested in the deer herd and the game-cover plantings, and they always insist on being shown the second oldest planting of the Multiflora Rose in the United States.

Missouri spring weather, being what it is, there is no way of planning the talk or the field trip far in advance. Small groups can gather for a talk in the Manager's Office or in the Main Gate waiting room during inclement weather. If the weather precludes a field trip, then the talk must cover the allotted time and neither the waiting room nor the office is suitable for such meetings. In almost every group there are individuals who cannot make the long and sometimes hard walk over the trails. The answer to this problem appears to be the use of Kodachrome slides from our extensive collection to illustrate the talk. In this way both the person unable to make the walk, as well as the enthusiast who doesn't mind walking the trails in a

downpour, will be able to see the flowers at their best. This also is the only way visitors can see the plantings should the date set for the meeting prove to be too late in an early spring, or too early in a late spring. Kodachrome slides cannot be used unless a darkened room is available and the present meeting places cannot be darkened sufficiently. Some day we may have a suitable place at the Arboretum for showing films and colored slides, but at present it will be necessary to arrange for such a meeting in town.

The range of greenhouses containing the collection of orchid plants is open for inspection from 10 A. M. to 3 P. M. on week-days, but this is another story. It is only professional or amateur orchid growers who are interested in the experimental work carried on in these houses.

The management of the Arboretum is under the direction of Mr. A. P. Beilmann.

Orchids growing in the Arboretum greenhouses

Orchid Department at the Arboretum.—During the year 28,498 orchid plants have been repotted, using new peat. Of these, 23,298 were placed in 4-inch, 5-inch, or 6-inch pots; 950 were removed from the hydroponic bench and planted in peat in 3- or 4-inch pots; 4,200 seedlings were transferred from community pans into 2-inch pots; and 50 community pans were planted with seedlings removed from flasks.

The approximate number of flowering orchids in the Arboretum greenhouse range is 28,667; of unflowered seedlings, 31,216. The flowering plants include members of the hybrid Cattleya group, Vandas, Dendrobiums, Phalaenopsis, Cymbidiums, and botanicals.

The Anthurium collection has been entirely repotted. The Nepenthes collection was also repotted and many propagations made, particularly of the following outstanding varieties: *Dicksoniana*, *Dyeriana*, *Chelsoni*, *Balfouriana*, *Mixta*, and *Maxima*.

Improvements in the Arboretum growing houses during the year include the following: removing the old wooden staging from the tops of 20 benches and filling them with gravel; repainting the outsides of eight of the houses; and repainting the iron gutters inside four of the houses.

Mr. G. R. Lowry is the orchid grower at the Arboretum.

RESEARCH IN HORTICULTURE

Dr. Gustav A. L. Mehlquist, Research Horticulturist to the Garden and Associate Professor of Botany in the Henry Shaw School of Botany of Washington University, has continued his investigations on hybridization and cytogenetics in certain plants important to commercial floriculture.

Antirrhinum.—During the past year some 2,500 seedlings of diploid and tetraploid snapdragons have been grown in the Experimental Greenhouses for the purpose of extending the studies relative to the nature of gene segregation in tetraploids. It is planned to continue the studies as far as space will permit.

Chrysanthemum.—Selected seedlings from previous years are being propagated until sufficient information relative to their behavior in the exhibition houses is available to indicate what further crosses should be made.

Delphinium.—Hybridization between the red-flowered *Delphinium cardinale*, native to Southern California, and the garden forms of the *D. elatum* group has continued. Some 1,500 seedlings, mostly F_3's and backcrosses of derived red and pink seedlings to the *elatum* parent were grown in the greenhouse. Some beautiful pink and red seedlings were flowered but, unfortunately, their habit of growth is still too close to that of *D. cardinale* to make them suitable as garden plants. Their value lies in their red or pink

flower color combined with a number of genes from the *elatum* species. They are being used in back-crosses to the garden forms. In addition, vegetative propagation of the original parents and selected F_1's, F_2's and back-crosses has been carried on, partly to provide materials for a comprehensive cytological study of the key plants of the project and partly because in many instances three and four years are required to evaluate properly the breeding value of a particular seedling.

Dianthus.—

A. Carnations: The research on inheritance in tetraploid carnations is being continued. Four tetraploid seedlings developed in cooperation with the University of California are now out on trial with selected growers in the St. Louis area and with four eastern university experiment stations. At least another year is required before any opinion as to the commercial value of these seedlings can be formed. Certain diploid lines are being increased for use in cooperative studies on the chemistry of the flower pigments with Dr. T. A. Geissman, of the University of California at Los Angeles. This phase of the project had to be discontinued during the war and, due to the subsequent loss of several important lines, some time will be required before all the desired genotypes will be available again.

B. Pinks: Due to lack of suitable out-of-door space, very little has been done on this project during the past year. The genus Dianthus contains over 200 species most of which are native to Europe and Asia. Interspecific hybridization occurs frequently in nature and is easily accomplished under garden conditions. This, in connection with the fact that many of the species are native to areas having essentially the same climate as St. Louis, makes it plausible that if space were available for trying various species and hybrids, pinks better adapted to the climate of this area could be obtained. It is hoped to obtain some fenced space to keep out rabbits and "two-footed itchy-fingers" for this and other projects.

Orchids.—

During the past year a considerable portion of the time available for research has been spent on cytological studies in various genera of orchids.

A. Paphiopedilum: The studies on polyploidy reported in the Garden BULLETIN of December, 1947 have been extended and amplified.

B. Cymbidium: A similar study is being made in this genus. Two well-known and much-used stud plants, namely, *C. Pauwelsii* var. COMPTE DE HEMTINNE and *C. Alexanderi,* WESTONBIRT var., are tetraploids and probably owe their marked influence on their progeny to the tetraploid condition. Numerous excellent crosses have been raised by using either of these plants as one parent. Apparently large numbers of vigorous seedlings are

obtained in crosses with diploids and all such seedlings that have been investigated so far have been triploids. These seedlings show strongly the influence of the tetraploid parents. They are generally superior to diploids in texture and shape of flower but set little or no seed.

C. Cattleya, Laelia, Brassavola: A preliminary investigation has disclosed tetraploidy in these genera too, and in their hybrids. Whereas in Cymbidium and Paphiopedilum an increase in chromosome numbers generally causes increased size of flower and plants in addition to improved texture, tetraploidy in the Cattleya group appears to cause but little if any increase in size but a marked improvement in texture. As in Cymbidium, large numbers of vigorous seedlings apparently are obtained in crosses between tetraploids and diploids. Such seedlings flower well and tend to be greatly superior to diploids in texture but ordinarily there is difficulty in obtaining seed from them. All in all, studies tend to indicate the desirability of using tetraploids in crosses with diploids to produce plants for commercial cut-flower production. Crosses between tetraploids only will probably produce the better exhibition plants.

Previous studies have disclosed tetraploidy in Phalaenopsis also, so that it seems safe to say, as with many other horticultural plants, that tetraploids have gradually been favored by the gardener selecting for substance and greater size of flowers. Although great strides have been made through selection with little or no knowledge of the real causes involved, there is no doubt that the greatest advances in future orchid breeding will come through the conscious selection of genotypes cytologically and genetically suited for the purpose in mind.

The spring garden course for amateurs was given by Dr. Mehlquist as usual, on Wednesdays, from February to May.

RESEARCH AND INSTRUCTION

Dr. Carroll W. Dodge, Mycologist to the Garden and Professor in the Henry Shaw School of Botany of Washington University, has spent much of the time available for research in identifying miscellaneous collections sent in by correspondents from northern Quebec, the eastern United States, especially Florida, Kansas, Texas, Utah, Nevada, New Mexico, Arizona, Lower California, Standley & Steyermark's large collection from Guatemala, and smaller collections from other tropical American countries, particularly Venezuela and from the Hawaiian Islands. With the reorganization of the herbarium Dr. Dodge assumed responsibility for routine work on the algae as well as the fungi and lichens. All of the exsiccati sets in book form have been assembled in steel cases in his office and the adjoining hallway, and the index cards assembled in a single file from various parts of the herbarium.

Messrs. George A. Llano and Marion T. Hall continued insertion of accumulated specimens in the lichen herbarium until June 1. Routine determinations of cultures of fungi, both human and plant pathogens, have been made for correspondents. The study of the collections of the U. S. Antarctic Service Expedition (Admiral Byrd's Third Expedition) has been continued, and the report on the Australian Antarctic expeditions published in July. Mr. George A. Llano completed his monograph of the Umbilicariaceae and joined the staff of the U. S. National Herbarium as Associate Curator of Cryptogams on July 1.

The usual courses of instruction at Washington University were given. Mr. Daniel O. McClary gave the course in General Bacteriology during the summer sessions, and Dr. Richard R. Marsh has continued to give this course in University College.

Dr. Edgar Anderson, Geneticist to the Garden and Engelmann Professor of Botany in the Henry Shaw School of Botany, has devoted much of his time in the last year to two books, both of which are now in the press. One of these is a revision of a standard reference work on corn; the other is a short monograph on the various effects of hybridization under natural conditions, with particular reference to methods by which these can be measured and analyzed. Aside from graduate and undergraduate teaching in the School of Botany, the remainder of his time has largely been given over to studies of maize and its relatives. To provide the broad background necessary for understanding certain phases of the problem he has spent one day a week assisting Dr. Van Schaack in ordering up those sections of the grass herbarium which include maize and all its possible relatives. The whole problem of relationships in this part of the grass family is so technical that much of the material in the Missouri Botanical Garden herbarium had scarcely been touched since the days of Dr. Engelmann. Helping put this material into an effective working condition has not only made the herbarium specimens available for immediate reference, it has provided an understanding of the phylogeny of these groups of grasses which could be equalled in no other way.

One of the results of the conference on maize inflorescences, mentioned in last year's report, has been a special number of the ANNALS given over to a series of papers, all of which deal in one way or another with the morphology of the ear and tassel in *Zea Mays*. One of the outstanding contributions to this special number is a portion of the Doctor's thesis presented last spring by L. W. Lenz, who for two years was the holder of a special fellowship from the Pioneer Hi-Bred Corn Breeding Company. Dr. Lenz's thesis was concerned with the detailed anatomy of the corn cob, a structure so complicated and so difficult to dissect that practically nothing had previously

been reported on the subject. His results will provide basic information, on the one hand, to those who are interested in the origin and relationships of maize and, on the other, to those who are concerned with the utilization of cobs for feeding or for industrial purposes.

In an earlier number of the ANNALS, Dr. Anderson and his associate, Dr. William L. Brown of the Pioneer Hi-Bred Corn Company, published a final report on the old southern dent varieties of the southern states. This, combined with the previous report on the northern flints, virtually completes their survey of the common field corns of eastern North America.

During the summer months Dr. Anderson was a guest of the California Institute of Technology at Pasadena where he took advantage of the longer growing season to study various exotic varieties of maize. A number of maize geneticists from various parts of the United States were also in residence there for the summer, and it was possible to integrate his research program with theirs in a number of joint projects.

For a portion of the year Sr. Felix Agramont of Mexico City worked in Dr. Anderson's laboratory on a special fellowship from the Rockefeller Foundation. With Dr. Anderson he made a comprehensive survey of kernel type in dent corn which has been worked up for publication. In September, Mr. Donald Duvick, a graduate of the University of Illinois, arrived to continue these studies under the auspices of the Pioneer Hi-Bred Corn Breeding Company. The composition of the kernel of maize is of basic importance to its use, yet the genetics of kernel differences is so complex that little has been published on the subject. Sr. Agramont's survey has provided the basis for a somewhat new approach to the subject, and Mr. Duvick is already making promising headway.

At the same time that new metal cases were installed in the main herbarium, the old wooden cases in which Dr. Anderson's maize herbarium had been stored were replaced by modern steel equipment. The entire collection is now housed in insect-proof cases and is being indexed for ready reference.

Dr. Robert E. Woodson, Jr., Curator of the Herbarium and Professor in the Henry Shaw School of Botany of Washington University, beside his new duties as Curator of the Herbarium, has conducted his usual classes in General Morphology and Taxonomy, particularly of the Missouri Flora, and Morphology and Taxonomy of Angiosperms. He has had very little time for research during the year, although he has continued, in a general way, to assist Dr. Schery in the compilation of the "Flora of Panama." He also has supervised the following graduate research students majoring in taxonomy of the Angiosperms: Fred G. Meyer, who is at present completing a revision of the North and Central American species of Valeriana; Richard W. Holm, engaged in a revision of Sarcostemma and certain other studies of Tropical

American Asclepiadaceae; Ko Ko Lay, who finished a revision of Heliocarpus and has begun a monograph of the difficult genus Triumfetta; David J. Rogers, now well advanced in a study of the North and Central American species of Stillingia; Hugh H. Iltis and George Freytag, engaged in preliminary studies of the genera Cleome and Guazuma, respectively.

Dr. Henry N. Andrews, Jr., Paleobotanist to the Garden and Acting Dean of the Henry Shaw School of Botany, spent the greater part of the month of June collecting fossil plants in the coal fields of West Virginia, Indiana, and Illinois, in company with Mr. Robert W. Baxter and Mr. Sergius Mamay, graduate students in paleobotany. The object of the summer's collecting was chiefly to locate new sites producing the petrifactions known as coal balls. They were fortunate in finding a number of new places in Illinois where collecting may be expected to continue for some few years, and in southern Indiana one mine was found from which were brought back nearly two tons of specimens. The cutting and study of this material will continue through the winter and probably for some time to come in view of the large amount on hand. A short collecting trip was also made to Des Moines where a few coal mines were visited in company with Mr. Frederick O. Thompson, who has also continued his interest in our paleobotanical work with the donation of a few specimens during the course of the year.

The work of Dr. Robert W. Schery, Research Associate at the Garden and Assistant Professor in the Henry Shaw School of Botany, has been directed along two main channels during the year: (1) technical research on the "Flora of Panama," (2) popular and semi-scientific investigations of local significance particularly related to gardening and local flora which were reported upon in the current volume of the BULLETIN. In addition to minor duties, lectures, public information calls, reporting flowering dates to the Allergy Laboratory of Washington University Medical School, etc., he gave the courses in General Botany and Economic Botany at Washington University and collaborated in the courses in Plant Materials and General Biology. During the summer Dr. Schery was visiting lecturer at the University of Wisconsin, where he gave courses in Dendrology and Systematics, and engaged in research on economic botany.

In cooperation with Dr. Woodson he edited and contributed to the writing of Part V, Fasc. 1 of the "Flora of Panama," appearing in the February number of the ANNALS. Research has continued toward subsequent publication of various plant families for the "Flora of Panama," particular attention having been given to the Leguminosae. During June Dr. Schery spent several days examining the Leguminosae at the various eastern herbaria—the United States National Herbarium and the Department of Agriculture at Washington, D. C., the New York Botanical Garden, and

the Gray Herbarium and the herbaria of Arnold Arboretum and the Botanical Museum, of Harvard University.

Dr. Rolla M. Tryon, Jr., Assistant Curator and Associate Professor in the Henry Shaw School of Botany of Washington University, joined the staff in April, 1948, coming from the University of Minnesota at Minneapolis. Dr. Tryon's first duties were to order up portions of the herbarium previously given only maintenance attention. During the summer he worked with Dr. Woodson in reorganizing the herbarium. In August Dr. Tryon taught courses in Summer Flora and Aquatic Plants at the University of Minnesota Biological Station, Lake Itasca, Minnesota. The remainder of the year he has devoted his energies primarily towards organization and presentation of the course in Ferns, Gymnosperms and Mosses for the Henry Shaw School of Botany. Dr. Tryon's research activity has included studies on the ferns and fern allies of Minnesota and on the fern genus Woodsia.

Degrees.—At the June 1948 commencement, the degree of Doctor of Philosophy was conferred upon Lee Wayne Lenz, B.S., Montana State College, M.S., Louisiana State University (Cytogenetics), and Anna Caroline Raut, B.S., University of Illinois (Genetics). The degree of Master of Arts was conferred upon KoKo Lay, B.S., University of Rangoon (Taxonomy), Jonathan Deininger Sauer, A.B., University of California (Genetics), Sergius Harry Mamay, B.S., University of Akron (Paleobotany), and Richard William Holm, A.B., Washington University (Taxonomy).

Graduates and Fellows.—The following graduate students were registered in the Henry Shaw School of Botany in 1948:

Graduate Assistants: George Freytag, A.B., University of Wyoming (Taxonomy); Marilyn Amy Gage, B.S., Pennsylvania College for Women (Genetics); Marion Trufant Hall, B.S. and M.S., University of Oklahoma (Ecological Genetics); Hugh Iltis, B.S., University of Tennessee (Taxonomy); Daniel McClary, B.S., Southeastern State Teachers' College, Durant, Oklahoma (Bacteriology); Dennison Harlow Morey, A.B., Washington University (Horticulture); Constance L. Ogden, B.A., Coe College (Paleobotany); Sidney Rodenberg, A.B., Washington University (Microbiology); David J. Rogers, A.B., University of Florida (Taxonomy); Milton Zucker, A.B., Washington University (Physiology).

Burmese Government State Scholarship: Ko Ko Lay, B.S., University of Rangoon, M.S., Washington University (Taxonomy).

Henrietta Heerman Scholar: Robert Baxter, A.B. and M.S., Washington University (Paleobotany).

University Fellowships: Sergius H. Mamay, A.B., University of Akron, M.A., Washington University (Paleobotany); Fred G. Meyer, A.B. and M.S.,

Washington State College (Taxonomy).

Special Research Assistantship at Brookhill Farm: Alfred G. Etter, A.B., Washington University (Ecology).

Special Research Grant from Pioneer Hi-Bred Corn Company: Donald N. Duvick, B.S., University of Illinois (Genetics).

Independent Students: Harriet L. Arey, A.B., Washington University (Microbiology); John H. Ayers, A.B., Des Moines University, M.A., University of Cincinnati (Mycology); Harrison A. Hoffman, B.S., McKendree College, M.S., University of Illinois (Microbiology); George A. Llano, A.B., Cornell University, M.S., Columbia University (Lichenology); Henry A. McQuade, A.B., Washington University, M.A., Missouri University (Cytology); Frank L. Mercer, B.S., St. Louis College of Pharmacy, M.S., University of Michigan (Physiology); Alice F. Tryon, B.S., Milwaukee Teachers' College, Milwaukee, Wis., M.S., University of Wisconsin.

Published Articles.—

Allen, Paul A., Representative in the Tropics: Rediscovery of the Rare Chinela. Orchid Lore 2^1:3–5 (reprinted from March 1939 Garden BULLETIN).

Anderson, Edgar, Geneticist: Hybridization of the Habitat. Evolution 2^1:1–9; Missouri Asters for Missouri Gardens. Garden Life 20^{13}:5–6; The Red Cedar. Mo. Bot. Gard. Bull. 36:86–92; Vegetable Gardening in Hong Kong. *Ibid.* 141; What Will Corn be Like 50 Years from Now? Capper's Farmer 59^5:9, 81; with William L. Brown: A Morphological Analysis of Row Number in Maize. Ann. Mo. Bot. Gard. 35:323–336; The Southern Dent Corns. *Ibid.* 255–268.

Andrews, Henry N., Jr., Paleobotanist: Fossil Tree Ferns of Idaho. Archaeology 1:190–195; Metasequoia and the Living Fossils. Mo. Bot. Gard. Bull. 36:79–85; A Note on *Fomes idaboensis* Brown. Ann. Mo. Bot. Gard. 35:207; The Royal Pines of New Hampshire. Appalachia. Dec. number; Some Evolutionary Trends in the Pteridosperms. Bot. Gaz. 110:13–36; with Robert W. Baxter: Contributions to Our Knowledge of American Carboniferous Floras. X. An Osmundaceous Stem from Iowa. Ann. Mo. Bot. Gard. 35:193–201; with Sergius Mamay: A Crossotheca from Northern Illinois. *Ibid.* 203–204.

Baxter, Robert W., Henrietta Heermann Scholar in Shaw School of Botany: A Study of the Vegetative Anatomy of the Genus Sphenophyllum. Ann. Mo. Bot. Gard. 35:209–231; with Henry H. Andrews, Jr.: Contributions to Our Knowledge of American Carboniferous Floras. X. An Osmundaceous Stem from Iowa. *Ibid.* 193–201.

Beilmann, August P., Manager of the Arboretum: Eastern Missouri Honey Plants. Amer. Bee Jour. 50:411–415; Efficient Fire Fighter. Parks

& Recreation 31:533–534; The Hardeman Garden. Mo. Bot. Gard Bull. 36:121; Missouri's Oaks. *Ibid*. 143–148; Rise and Fall of the Sap in Trees. Trees 8^{6}:26–28; Three Evergreen Barberries. Mo. Bot. Gard. Bull. 36:58; The Wafer Ash. Amer. Bee Jour. 50:369.

Brenner, Louis J., of the Arboretum staff: The Golden Seal. Mo. Bot. Gard. Bull. 36:156.

Cutak, Ladislaus, in charge of Succulents: *Begonia MacDougallii*. The Begonian 15:231 (reprinted from Feb. 1948 Garden BULLETIN); Down Tehauntepec Way. Jour. Cactus & Succ. Soc. Amer. 20:63–68; Into the Canyon of Old Men. The Spine (Jour. Cactus & Succulent Soc. Australia) 1:72–76; Journey to a Rain Forest in Chiapas. Mo. Bot. Gard. Bull. 36:35–46; Men Who Make Spine—No. 2. The Spine 1:90–92; Missouri Botanical Garden's Desert Collection. Jour. Nat. Cactus & Succ. Soc. [British] 3:14–15; Spine Chats. Monthly contribution in Jour. Cactus & Succ. Soc. Amer. Vol. 20; What is a Succulent? Mo. Bot. Gard. Bull. 36:111–118.

Dodge, Carroll W., Mycologist: Antarctic Research Expedition Report. Ser. B. (Zool. & Bot.). Vol. 7. Lichens and Lichen Parasites.

Etter, Alfred G., Graduate Student, Shaw School of Botany: Goodbye to the Osage. The Land 7:83–84; Seeds that Ride Livestock. Mo. Bot. Gard. Bull. 36:170–172.

Kohl, Paul A., Floriculturist: Dusting and Spraying of Roses. Garden Path 18^{3}:9 (reprinted from March 1947 Garden BULLETIN); Ornamental Gourds. Gourd Seed 9:4–5 (reprinted from February 1947 BULLETIN).

Llano, George A., Graduate Student, Shaw School of Botany: Economic Uses of Lichens. Econ. Bot. 2:15–45.

Mamay, Sergius, Graduate Student, Shaw School of Botany: with Henry N. Andrews: A Crossotheca from Northern Illinois. Ann. Mo. Bot. Gard. 35:203–204.

Mehlquist, G. A. L., Research Horticulturist: The Value of Organic Matter in Gardening. The Begonian 15:226–229; Delphiniums. Garden Life 20^{15}:5–7; Fundamentals of Floriculture. South. Flor. 61^{19}:9–10, 58–61; 61^{20}:12–13, 63–65; Flor. Exch. 91^{9}:11, 44, 46; Some Observations on Orchid Growing in England. Orchid Digest 12:152–156.

Moore, George T., Director: The Missouri Botanical Garden. Arboretum Bull. [Univ. Washington] 10^{4}:4–5, 28; Magnolias in St. Louis. *Ibid*. 16.

Morey, Dennison H., Graduate Assistant, Henry Shaw School of Botany: An Aluminum Greenhouse Bench. Mo. Bot. Gard. Bull. 36:107–109; Forcing the Madonna Lily. *Ibid*. 149–154; The Giant Carrion Plant. *Ibid*. 60–61; How Plants Got Classified. *Ibid*. 102–106; with Richard W. Holm: We Consider the Lilies. *Ibid*. 51–53 (reprinted in Southern Florist 61^{1}:13, 65–66, under title "Lilies Suitable for Garden Planting in Midwest Area");

with Robert W. Schery: How to Heat with Wood. Amer. Forests 54:21, 42–43.

Pring, George H., Superintendent: Columneas as Greenhouse Plants. Mo. Bot. Gard. Bull. 36:122–123; Orchid Show at Missouri Botanical Garden. Amer. Orchid Soc. Bull. 17:154; *Nymphaea* "Bob Trickett." Mo. Bot. Gard. Bull. 36:155–156; Three New Water-lily Hybrids. *Ibid.* 62–65; with David H. Fairburn: Light Requirements for Orchids in the Midwest. Orchid Lore 2^3:3–26 (reprinted from Feb. 1945 Garden BULLETIN).

Schery, Robert W., Research Associate: Bark Instead of Nails. Mo. Bot. Gard. Bull. 36:99–101; Jewels of the Leguminosae. *Ibid.* 137–139; The Lawn—To Mow or Not to Mow. *Ibid.* 53–57; Organic vs. Chemical Fertilizers. *Ibid.* 73–76; Plants Say When it's Springtime. *Ibid.* 76–78; Ribbon-candy Vines. *Ibid.* 119–120; Starting Seeds for the Spring Vegetable Garden. *Ibid.* 47–48; Watering the Home Lawn. *Ibid.* 95–98; Winter Adventure with Missouri Springs. *Ibid.* 161–165; with George K. Richardson: The Fleeting Frost Flowers. *Ibid.* 166–168; with Dennison H. Morey: How to Heat with Wood. Amer. Forests 54:21, 42–43; with Robert E. Woodson, Jr., Flora of Panama, Part V, Fasc. 1. Ann. Mo. Bot. Gard. 35:1–106; with Ellen D. Kern: Laboratory Outline for Elementary Botany. 1947, reprinted in 1948. Prior publications omitted from last annual report: Manioc—A Tropical Staff-of-Life. Econ. Bot. 1:20–25; Strangler Figs. Nat. Hist. 55:438. 1946; An Expert Reviews the Fabulous 2-4-D. Modern Cemetery 57:51–52. 1947 (reprinted from Garden BULLETIN); a review of Fairchild's "The World Grows Round My Door." Post-Dispatch, April 5, 1947.

Tryon, R. M., Jr., Assistant Curator of the Herbarium: with F. K. Butters: A Fertile Mutant of a Woodsia Hybrid. Amer. Jour. Bot. 35:132; with L. E. Booher: A Study of Elymus in Minnesota. Rhodora 50:80–90.

Woodson, Robert E., Jr., Curator of the Herbarium: Apocynaceae and Asclepiadaceae, in Maguire et al., Plant Exploration in Guiana in 1944, etc. Bull. Torr. Bot. Club 75:553–561; Gynandropsis, Cleome, and Podandrogyne. Ann. Mo. Bot. Gard. 35:139–146; Miscellaneous New Apocynaceae and Asclepiadaceae. *Ibid.* 233–238; Hernandiaceae and Capparidaceae, in Woodson & Schery's "Flora of Panama," Part V, Fasc. 1. *Ibid.* 68–71; 75–99.

Scientific and Popular Lectures.—

Dr. Henry N. Andrews: May 18, before the St. Louis Osteopathic Auxiliary, "Ancient Plants and the World They Lived In."

Mr. August P. Beilmann: February 17, before the Garden Club of St. Louis, "Trees"; March 14, Washington (Mo.) Churchman's Brotherhood, "The Mechanism of Tree Growth"; October 26, at Jefferson City, Mo., before the Missouri State Sewerage and Waterworks Conference, "Dress up the Waterworks."

Mr. Ladislaus Cutak: "Gardens of Florida": January 12, before First Ward Improvement Association of Northwoods; April 13, Nazareth Brotherhood of Nazareth Evangelical Church. "Plant Hunt in Old Mexico": January 16, before Harmony Circle of the Rosemary Garden Club; February 20, Clayton Garden Club, No. 1. "Cacti and Succulents": January 22, before Sunnyside Garden Club at Ferguson, Mo.; March 25, Home and Garden Section of the Women's Club of Richmond Heights; April 1, Women's Guild of Bethany Evangelical and Reformed Church; September 7, the Northwoods Garden Club; November 19, Clayton Garden Club, No. 4. "The Fascinating Cactus Family," March 8, before the Men's Garden Club of Webster Groves. "Insect Pests and Diseases of Cactus Plants," March 14, before the Henry Shaw Cactus Society. "Orchid Cacti," April 11, before the Henry Shaw Cactus Society. "Four Seasons in the Garden": May 3, before the Kirksville Floriculture Club at Kirksville, Mo.; May 4, before the Des Moines Cactus Society, at Des Moines, Iowa. "Mexico in Kodachrome": May 3, before the Kirksville Floriculture Club at Kirksville, Mo.; May 4, Des Moines Cactus Society at Des Moines, Iowa; May 18, the St. Louis Women's Auxiliary of the Railway Mail Association; June 2, North St. Louis Real Estate Salesmen's Association; October 6, the Women of St. Mark's English Lutheran Church; November 3, Sigma Alpha Epsilon Mothers' Club; December 3, seminar Henry Shaw School of Botany. "The Tropical Greenhouse in the Role of a Civic Enterprise," May 4, before the Park Board and City Council of Des Moines, Iowa. "Grafting Cacti," May 9, before the Henry Shaw Cactus Society. "Camera Trails among Flowers," November 24, before the Science Section of the Wednesday Club of St. Louis. "Comments on the Fall Cactus Show," December 12, before the Henry Shaw Cactus Society.

Mr. Paul A. Kohl: January 16, before the Clayton Garden Club, Group 4, and January 26, before the Little Gardens Club, "The Care of Roses"; February 11, Webster Groves Garden Club, Group 11, "Rose Culture"; March 19, Clayton Garden Club, No. 3, "Roses"; November 12, Webster Groves Garden Club, Group 4, "Chrysanthemums."

Dr. G. A. L. Mehlquist: January 20, before the Missouri State Florists' Growers School, "Fundamentals in Floriculture"; February 16, Rowena Clark Garden Club of Kirkwood, "Orchid Culture and Orchid Breeding"; March 10, Webster Groves Nature Study Society, "Orchid Culture"; April 12, Men's Garden Club of Webster Groves, "Factors Influencing Plant Growth"; April 13, Kirkwood Kiwanis Club, "Orchids and Orchid Growing"; April 20, at Los Angeles, Calif., before the Orchid Society of Southern California, "Orchid Growing in England"; April 23, at Pasadena, Calif., seminar of the California Institute of Technology, "Orchids in Relation to Breeding Practices"; April 27, at Pasadena, Calif., Cymbidium Society, Inc.,

"Growing of Cymbidiums and Cypripediums in England"; April 28, at Santa Barbara, Calif., Santa Barbara Orchid Society, "Some Observations on Orchid Growing Made in England during the Summer of 1947"; June 15, Missouri State Florists' Association convention, at St. Joseph, "Fundamentals in Floriculture"; July 16, St. Louis Rose Society, "Role of Genetics and Cytology in Rose Breeding"; September 10, meeting of American Soc. Hort. Sci., at Cincinnati, "Inheritance of Rust in the Snapdragon"; September 22, Missouri State Flower Arranging and Judging School, "Fundamentals of Horticulture"; October 30, American Orchid Society, "Chromosome Numbers and Their Significance in Orchid Breeding"; October 13, Webster Groves Garden Club, Group 7, "Planning Your Garden"; November 19, Greater St. Louis Flower Growers' School, "Cut Flower Production in California in Relation to the St. Louis Market"; December 17, Consolidated Flower Growers of St. Louis, "Factors of Temperature and Light Affecting Flower Production."

Mr. George H. Pring: January 12, at annual joint meeting of two afternoon Garden Clubs in Northampton (St. Louis Co.), conducted a plant clinic; January 13, at Cleveland, Ohio, before the Cleveland Orchid Society, "Development of Orchids from Seed to Flower"; "Four Seasons in the Missouri Botanical Garden" (illust.): at Ft. Lauderdale, Fla., February 19, at the Sea Ranch Hotel; February 21, Ft. Lauderdale Federated Garden Clubs; February 23, at the Riomar Club, Vero Beach. March 23, Boy Scouts of Shaw Ave. Methodist Church, "Gardening"; March 24, Stephens College Alumnae Club, "Orchids"; March 31, Missouri State Judging School, "Horticulture"; April 13, Highland Women's Club, Highland, Ill., "Henry Shaw's Garden"; April 29, upper-grade pupils of Mullanphy School, "Romance of the Orchid"; October 21, Missouri School for the Blind, "Plant Exploration in Central and South America"; October 29, annual meeting of the American Orchid Society, "Four Seasons in the Garden," and "Orchids from Seed to Flower"; November 5, meeting of St. Louis Horticultural Society, "English Gardens."

LIBRARY AND PUBLICATIONS

The greatest accomplishment of the library during 1948 was in bringing some semblance of order out of the chaos of the last few years. Four years ago, when it seemed that the congestion in the library had reached a peak, the downtown business office was moved to the administration building at the Garden, and the large folio room and library office was assigned to the Secretary. Somehow, the folios were crowded into the room already used as a reading room as well as office of the Librarian-Editor, and the two other members of the library staff found places for their desks between the cases

in the south room. Then in 1947 about 800 lineal feet of books had to be moved to make room for the elevator then being installed. There was simply no available space for these books so they were piled on top of cases, on tables, in window-sills, etc. After the elevator was installed advantage was taken of the moving necessary to respace all the books in the library, and to make more room by discarding all the extraneous material which had accumulated during the years. A part-time assistant was obtained during the summer, and with her help all the books in the southeast part of the basement were cleaned and rearranged. The horticultural folio journals in the basement were moved from the cases along the walls to an alcove which had been fitted with new shelves. In the cases thus emptied were placed the seed-catalogues and books of doubtful value. If the latter are not consulted in the next years they will eventually be disposed of.

This shifting and discarding meant, of course, that every book or pamphlet had to be examined and evaluated. Some of the books discarded were valuable to other types of libraries, being on such subjects as engineering, hygiene, medicine, zoology, etc. The zoology department of Washington University purchased 173 volumes on physiology and biochemistry which had been on indefinite loan to their biology library since 1927, and 118 books were sold to dealers. Over 400 pamphlets on non-botanical subjects or which were reprints from serials already in our collection were either given away or discarded. All this work was laborious and time-consuming, and before it was completed the School of Botany had opened. With routine library and publication work occupying all the time of the staff during the school term, it will be next summer before the reorganization work can be resumed.

Every book on the main floor (mostly journals) had to be shifted in a hurry for the five new cases ordered were not received until September and by that time some of the graduate students had arrived. Here too a few journals were moved to the "doubtfully needed" shelves but there was not time to sort them carefully. However, the sections Ae*α* (publications of academies, societies, etc.) and Ae*β* (botanical gardens) were merged. Both these sections are arranged according to country, and after the two World Wars most of the geographical classifications in the Ae*α* section had been brought up to date, but the section on botanical gardens, being small and relatively unimportant, was just as it always had been. Last summer, the books and pamphlets of German botanical gardens, the section most in need of revision, were entirely recatalogued and cross-references made where needed.

The physical condition of the library was somewhat improved during the year. In addition to the new steel cases on the first floor, previously

mentioned, six long wooden cases were built in the basement to contain the folio horticultural serials. The walls of the entire basement were painted white, making it many degrees lighter, and drop lights were installed in every aisle, with light switches at both ends of the main room. During the past ten years the amount of binding and repairing of books had been reduced to a minimum on account of the high cost, and while more binding was done in 1948 than in recent years some of the books are still in an appalling state.

The shifting and discarding of books may give enough space for another several years, but, except for the lighting, the working conditions in the library are poorer than in 1947. There is no place for additional tables, and when the public uses the library for reference work, as frequently happens, it is a problem where to put the reader. The current periodical file is separated, part being in the old lecture room and part in the librarian-editor's office. The desks of two members of the library staff are still crowded between bookcases. There is no room for cataloguing or for collating books for binding except at a reading table or at a librarian's desk.

Publications.—Volume XXXV of the quarterly ANNALS and Volume XXXVI of the monthly BULLETIN were issued during the year. The volume of the ANNALS contains 408 pages, 48 plates, and 103 text-figures, the November number being devoted to the papers which grew out of the Corn Conference held at the Garden in 1947. The BULLETIN contains 178 pages and numerous illustrations. On account of the high cost of publication the size of the BULLETIN has generally been kept down to 16 pages to an issue. The work of preparing the Garden publications for the printer is done by the Librarian. In December work was started on another printing of Henry Shaw's biography, the last edition of 5,000 copies, printed five years ago, being exhausted.

About half of the ANNALS copies are sent to other institutions (generally foreign) on an exchange basis, while the greater part of the BULLETIN goes to "Friends of the Garden." The exchange situation of the ANNALS is about as in 1947, when it returned to nearly pre-war status. Few Russian publications are received, although they have been requested many times. On the other hand, the Russians usually subscribe to what they want from us. Many German publications, including volumes for the five years past, came in during 1948, but the International Exchange Service still does not guarantee shipments to Germany except in the American and British zones.

Both the ANNALS and the BULLETIN are sold on subscription. The cash receipts, during the year, for all the Garden publications, including reprints and separate numbers of ANNALS and BULLETIN, "Flora of Missouri," etc., was $7,587.75.

Library Accessions: Three outstanding publications were acquired during the year. The most noteworthy of these was St. Hilaire's "Flora Brasilinae-meridionalis," published in 1825-1833, a work constantly referred to by students of South American botany. It is also one of the rarest of taxonomic publications, and when it was listed in an English catalogue no time was lost in ordering it. Another interesting book was the scarce Missouri Historical Society's reprint of F. A. Wislizenus' "Journey to the Rocky Mountains in the year 1839," which was presented to the library by Dr. Harold A. Bulger. As far as is known, there are only three copies extant of the original German edition (Ein Auslag nach den Felsen Gebirgen im Jahre 1839), which seems strange for it was printed in St. Louis in 1840. In 1912 the Missouri Historical Society published the English translation of the work, adding to it a biographical sketch of Wislizenus, who was a prominent St. Louis physician as well as a naturalist. The third outstanding acquisition was a series of folio maps of Mexico put out by the Mexican Secretaria de Agricultura y Fomento. Upon arrival the maps were mounted on muslin and inserted in an especially made loose-leaf binder so that they could be taken out and examined without danger of being torn.

Other important books received during the year, in addition to those usually found in a botanical library, were the following: Annals of Horticulture, Vols. 1-4, 1846-49; Bedevian, A. K., Illustrated polyglottic dictionary of plant names in Latin, Arabic, Armenian, English, French, German, etc.; De Vries, L., German-English science dictionary. 2nd ed.; Galleo, O., Natural history of the Danish lichens, Part VI; Good, R., The geography of the flowering plants; A Symposium on the use of isotopes in biology and medicine; Knight, R. L., Dictionary of genetics; Lutz, H. J. and R. F. Chandler, Jr., Forest soils; Moeller, H. F., Fungi of the Faroës. Pt. 1. Basidiomycetes; McFarland, J. Horace, Modern roses. III; Olney, S. T., Catalogue of plants collected by the botanical department of Providence Franklin Society in 1844; Oosting, H. J., The study of plant communities; Ravenel, Henry William, the private journal of, edited by A. R. Childs; Sanders' Complete list of orchid hybrids; Thurston, L. L., Multiple-factor analysis; Wolf, F. A. & F. T. Wolf, The fungi. 2 vols. Three new serials were subscribed to: Lotsya, Plants and Soil, and Vegetatio.

Visitors: In addition to the staff and students of the Shaw School of Botany and the staff of the Missouri Botanical Garden, the following out of-town visitors made use of the library during the year: Ing. Julian Acuña, of Estacion Experimental Agronomica, Habana, Cuba; Mr. Felix Agramont, of Rockefeller Foundation, Mexico City; Mr. Paul H. Allen, of Golfito, Honduras, C. A.; Mr. Earl E. Berkley, of National Cotton Council of America, Washington, D. C.; Dr. Jacob Bjerknes, of University of California, Los

Angeles; Dr. David H. Brown, of California Institute of Technology, Pasadena; Dr. William L. Brown, of Pioneer Hi-Bred Corn Co., Des Moines; Dr. Jose Castro, of Guatemala; Dr. Lincoln Constance, of Gray Herbarium of Harvard University; Dr. Hugh C. Cutler, of Chicago Natural History Museum (Field); Mr. J. Eric Culbertson, of Hobart, Tasmania; Prof. W. W. Dowdy, of Lincoln University, Jefferson City, Mo.; Mrs. George Elder, of the Lead Belt Garden Club, Arcadia, Mo.; Mr. Joseph Ewan, of Tulane University, New Orleans; Mr. John J. Finan, graduate student in history of science, Harvard University; Dr. Rudolf Florin, of Bergianska Tradgarden, Stockholm, Sweden; Dr. Seymour Fogel, of Queens College, Brooklyn, N. Y.; Dr. George J. Goodman, of University of Oklahoma; Dr. Charles B. Heiser, of University of Indiana; Dr. Walter H. Hodge, of University of Massachusetts; Dr. Margaret Kaiser, of Southern Illinois Normal University, Carbondale; Dr. Harlan Lewis, of University of California at Los Angeles; Dr. Marcos Lindenberg, of Circulo Paulista de Orquidofilo, São Paulo, Brazil; Dr. W. F. M. McDonald, of Ohio State University; Dr. J. J. Miller, of McMaster University, Hamilton, Ontario; Dr. Emery Moore, of Bailey Hortorium, Cornell University; Mrs. Iva Newman, of San Mateo, Calif.; Dr. Gerald B. Ownbey, of University of Minnesota; Dr. E. Percy Phillips, of South Africa; Prof. Kenneth Redman, of University of Georgia; Mr. Ralph E. Schmiedeskamp, of Montana State College, Bozeman; Dr. B. Sahni, of Lucknow University, India; Dr. Lloyd H. Shinners, of Southern Methodist University, Dallas, Texas; Dr. E. R. Spencer, of Lebanon, Ill.; Dr. Julian A. Steyermark, of Chicago Natural History Museum; Dr. Delbert Swartz, of University of Arkansas; Dr. M. J. Thirumalachar, of Malleswaram, Bangalore, India; Dr. Frans Verdoorn, Director Santa Anita Botanic Garden and Editor *Chronica Botanica;* Dr. Walter B. Welch, of Southern Illinois Normal University, Carbondale.

Groups visiting the library during the year were the following: biology classes from Harris Teacher's College, conducted by Dr. Lilian Nagel, Instructor in Botany; students in floriculture, University of Illinois; students in the garden course sponsored by the Landscape and Nurserymen's Association of Greater St. Louis; botany students of Springfield High School, Springfield, Ill., accompanied by their teacher, Miss Ruth Wood; class in biology from Carson College, Fairfield, Iowa, accompanied by their teacher, Mrs. F. W. Van Ohlen; students in dendrology, University of Missouri, accompanied by their professor, Dr. R. E. McDermott.

Statistical Information.—There have been donated to the library or received in exchange for our publications during the year 446 books valued at $1,277.28, and 728 pamphlets valued at $230.56. The purchases consisted of 212 books bought at a cost of $1,063.38, 17 pamphlets and parts of

volumes at a cost of $47.65, and the set of Mexican maps previously mentioned costing $30.00. The number of books sold was 291 for $894.99; and 42 books and 451 pamphlets were discarded. The library now contains 58,303 books, 101,031 pamphlets, and 357 manuscripts. The number of index cards now totals 1,119,669, of which 6,888 were added during the year, 627 having been written by Garden employees and 6,261 purchased; 290 cards were discarded. There were 245 books bound or repaired during the year.

ANNUAL BEQUESTS

The Annual Flower Sermon "On the goodness of God as shown in the growth of flowers, fruits, and other products of the vegetable kingdom," provided for in the will of Henry Shaw, was preached at Christ Church Cathedral, on Sunday, April 11, by the Rt. Rev. Theodore P. Ferris, Rector of Trinity Church, Boston, Mass.

The Gardeners' Banquet Fund was used to provide turkeys for employees at Christmas.

ATTENDANCE FOR 1948

(Not including visitors to Arboretum)

	Week-days	*Sundays*
January	1,892	1,315
February	4,119	7,530
March	5,070	10,434
April	8,844	9,300
May	13,110	13,106
June	11,681	5,902
July	14,731	5,138
August	14,367	9,169
September	6,313	13,977
October	11,741	10,745
November	11,700	14,006
December	3,788	8,460
	107,356	109,082
		107,356
Total		216,438

Respectfully submitted,

GEORGE T. MOORE, *Director.*

THE MISSOURI BOTANICAL GARDEN

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SOME FACTS ABOUT THE GARDEN

The Missouri Botanical Garden was opened to the public by Mr. Henry Shaw about 1860. From that date until his death in 1889 it was maintained under his personal direction. Although popularly known as "Shaw's Garden" the name Missouri Botanical Garden was chosen by Mr. Shaw and he definitely indicated that he wished it called by that name. The Garden passed at his death into the hands of a Board of Trustees, designated in Mr. Shaw's will, and the Board so constituted, exclusive of certain ex-officio members, is self-perpetuating. By a further provision of the will the immediate direction of the Garden is vested in a Director, appointed by the Board. The Garden receives no support from city or state but is maintained almost exclusively from the estate left by Henry Shaw. Since 1939 many Garden Clubs and interested individuals have contributed to a "Friends of the Garden Fund" which is used in developing the new Arboretum, located at Gray Summit, Mo. The Arboretum (1) serves as a source of plants, trees and shrubs for the city Garden; (2) affords areas for gradually establishing a pinetum, a wild-flower reservation and various other features on a scale not possible in the city; (3) provides greenhouses for some 20,000 orchid plants.

The city Garden comprises 75 acres, where about 12,000 species of plants are grown, both out of doors and under glass. It is open every day in the year except New Year's Day and Christmas; week days, 8:00 a. m. until 7:00 p. m.; Sundays, 10:00 a. m. until 7:00 p. m. The greenhouses are closed every day at 5:00 p. m.

The main entrance to the Garden is at Tower Grove and Flora Place, on the Sarah bus line (No. 42). The Tower Grove bus (No. 21), direct from downtown, passes within three blocks of the main entrance.

MISSOURI BOTANICAL GARDEN BULLETIN

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Cover: Fox and squirrel trails meet in Brookhill woods. Photograph by Alfred G. Etter.

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Please: Do not discard a copy of the Bulletin. If you have no further use for yours pass it along to a friend or return it to the Garden. Return postage will be guaranteed.

Missouri Botanical Garden Bulletin

Vol. XXXVII FEBRUARY, 1949 No. 2

CONSERVATION

In the belief that watershed protection by the growing of plant cover and the proper practice of conservation measures, not the impounding of streams after the rain and soil have once left the land, is the answer to many of Missouri's ills, we have asked several authors particularly qualified by their experience and training to contribute to this "conservation" issue of the BULLETIN. Certainly the matter is of pressing importance, and one in which all readers of the BULLETIN should be interested. Dr. Julian A. Steyermark, Research Associate to the Garden and Assistant Curator at the Chicago Natural History Museum, is one of the foremost students of floristics in Missouri and author of the well-known "Spring Flora of Missouri" besides many articles dealing with the flora of this state. Mr. Alfred G. Etter, a former student of the late renowned ecologist Aldo Leopold, is ecologist at the Brookhill Farm of Washington University and an advanced student in the Henry Shaw School of Botany. Dr. Edgar Anderson and Mr. A. P. Beilmann, frequent contributors to the BULLETIN, are respectively Geneticist to the Missouri Botanical Garden and Manager of the Arboretum at Gray Summit, where many aspects of land management have been tested. Mr. Louis G. Brenner, long interested in Missouri wildlife, acts as Mr. Beilmann's assistant at the Arboretum.

MEMOIRS OF MISUSE

ALFRED G. ETTER

Erosion is a perfectly natural process. Animal, vegetable, and mineral have an intense nostalgia for the sea. They will return there sooner or later by the route of running water. Under natural conditions this reunion is a deliberate and time-consuming drama. Under a human regime, however, the unities of time and place are frequently forgotten, and land meets sea over night.

I had never realized just how fast soil can actually leave the land until I had the opportunity to walk leisurely over fields and along creeks and gullies in the vicinity of Washington University's Brookhill Farm in Pike

Figure 1

County. The stories of man-made erosion told by simple scenes such as those shown in the accompanying photographs are convincing and unquestionable. One can come to no other conclusion than that something has been happening to the land with surprising swiftness.

Striking testimony to this accelerated removal of soil was found along the gulley pictured in fig. 1. A tile drainage pipe exposed by the cutting of this channel definitely indicated the recentness of this deep cut. Installation of such tiling was especially common in this area during the early 1900's. In many low fields, as in the present one, the soils were apt to remain heavy and wet until late spring. Crops were thus delayed. A popular remedy was to lay, at a depth of several feet, a system of porous pipe which would absorb water from the soil and convey it to a natural drain. A few of these old tile are still in place and continue to serve their purpose. Many, however, through mismanagement or neglect, have become useless or even dangerous.

Figure 2

The tile in the photograph is one of a series laid along the approximate path of the present drain. Most of the pipes are gone now, having fallen into the racing waters of some spring torrent. A few, such as this one, can still occasionally be found in protected meanders. It is apparent that three or four feet of soil have been removed above the pipe and at least an equal amount has disappeared below. Trees ten to fifteen years old growing in the gulley show that erosion of this 8-foot ditch has taken place largely between the probable dates of 1900 and 1935. Many factors have combined

to produce the results shown in this picture. The tile was laid in the lowest part of the field where most of the drainage was concentrated. Soil, loosened by the trenching necessary to bury the pipe, was easily removed by washing water. Dirt slipped into the crevices between tiles and was carried away, allowing the soil above to slump down. Gradually a straight channel resulted. Water poured down adjacent hill slopes whose fertility and water-holding capacity had been destroyed by uninterrupted crops of wheat. Inevitably the gully grew. Even at the present time accelerated erosion continues to some extent, encouraged by the inexcusable practice of allowing hogs into the drainages to root and break down the banks and to consume and trample young vegetation which, if given a chance, might stabilize the cut.

Equally recent and rapid has been the loss of soil from the surface of mistreated fields such as that illustrated by fig. 2. This "surficial" removal of material is frequently termed "sheet" erosion. A quarter or half inch of dirt a year is never missed when it is taken off evenly over the entire land surface. That is, it is not missed by the eye. Sooner or later, however, a reckoning comes. The fence shown on the left of fig. 2 is fairly new. It replaced an older one which was located in a similar position but was ten feet further up hill and had the large post at the extreme right at its corner. Where the old fence ran a distinct ridge is now visible. The soil of this ridge has the profile of an undisturbed soil and is rich and black. It has obviously never been plowed, having been protected by its line of posts. It is especially interesting and significant that this narrow strip of land supports a good stand of Blue Grass *(Poa pratensis)* while nothing but wiry Triple Awn Grass *(Aristida oligantha)* and other poor weeds grow on the parts of the fields that were ruthlessly cultivated. Stock range up and down this runner of Blue Grass, taking advantage of the remnant fertility. Roughly a foot of earth above and two feet below this ridge have been removed since the erection of the original fences.

A given amount of water running at a given speed can carry only a certain amount of soil. When the competition for transportation becomes acute, silts and sands drop out along the stream channels and the clays and dissolved minerals continue their homesick way to the bigger rivers. During the present century the load of soil, derived from such situations as those already illustrated, has apparently at times far exceeded the carrying capacity of existing streams, and striking deposits of material have thus accumulated.

Artifacts of the twentieth century buried in these deposits testify to a civilization advanced in the man-built realm of mechanics but stupid in the God-built world of nature. Uncovered by a recent flood, a radiator hood of

Figure 3

a 1919 automobile, shown in fig. 3, was discovered buried by 40 inches of alluvium. Fifteen-year-old sandbar willows grow in the soil above. Plainly the entire process of covering and uncovering has occurred in the last twenty years.

I was wandering along the rocky bed of Ramsey Creek one day recently, examining its deep banks of silt for evidence of Ice-Age plants or animals. I knew that much of our "high-bottom" land in this vicinity had originated during a period of time when an almost glacial climate held sway. Wind-blown dust from dried-up glacial lakes and flood plains had settled over much of the area near the Mississippi and Missouri rivers. Elimination of vegetation probably resulted from these dust storms. Freezing and thawing of unstable and unprotected soils caused slumping and movement of material down hill sides, and gradually river channels and valleys were clogged and filled with sediment to a considerable depth. Much of our richest river-bottom soil was so formed during this period of climatic instability. With the idea in mind that the high silty banks along the creek were all quite old, I was not prepared for the discovery of an upright buggy axle with barbed wires attached which had recently been uncovered by the action of the

Figure 4

stream from a six-foot deposit of soil (fig. 4). It was clear that an old fence line lay beneath this bank. Thus one is not only forced to picture an extensive deposition of silt some time since barbed-wire fencing became available (about 1880), but also to realize that these deposits have subsequently been cut through by the more recent activity of the creek. Man, in his uneducated way, has rivalled the glacial age in the production of unstable environments.

In fig. 5 the relationships between the glacial soil and man-induced deposition are plainly shown. Following the accumulation of high bottom lands (the light-colored soil on the left), streams, working through thousands of years, gradually cut their meandering channels. Within the last century these channels were then rapidly filled up with a dark alluvium which was rich with the lime and organic matter of eroded top soil (the dark fill on the right). It is in these concealed channels that recent relics such as the fence post are found. In the deposit shown in this photograph occasional walnut logs, some of which were definitely hewn with an axe, were encountered. Man has carelessly left his finger prints again. Long

winding colonnades of American elms, a few of which can be seen near the top of fig. 5, follow these channels. They are uniformly twenty-five to forty years old, and probably suggest the time when the channel was nearly filled.

It is interesting to notice the gentle slope of the old channel bank and to contrast it with the vertical creek banks of the present day. The indications are that before filling occurred the banks were stabilized by vegetation. Further proof of this is found in the cleanly washed beds of sand which coat the bed of the channel. We would probably be justified in visualizing the existence, in the first days of settlement (about 1820), of a slow-moving, clear water stream with a sandy bottom. With extensive clearing of the uplands for cultivation of tobacco, wheat, and corn, plus the introduction of

Figure 5

grazing herds into hilly woodlands, a fundamental change was worked. The loosened, exposed soil began piling up in every drain. Spring floods became veritable mud flows. Gradually, as we have seen, channels of even the main creek were filled to capacity. Then the floods had no place to go and spread out over low-lying crop land.

Strenuous efforts were made to get the orphaned stream back into a channel. Straightening of creeks became the order of the day. Vegetation which tended to hold back the waters was removed and occasional levees were built to channel the flow. Fields which had been exhausted beyond use were relegated to brush and poor pasture, thus tending somewhat to diminish the loss of soil. Slowly the stream's load was reduced. Straightened streams ran faster and thus could carry their load of sediment without depositing

it. Any top soil that was washed into a drain was certain to reach the Mississippi non-stop. There was no second chance in the valley. A new regime of straight, rapidly flowing, eroding streams cut down through older deposits and rapidly widened their channels, taking acres of high-bottom and channel-fill land together. Now even the highest floods seldom exceed the banks, though it is not because the amount of water flowing in the stream has been reduced. Actually little progress has been made in keeping rainfall on the land. The main difference is that the stream has provided itself with sufficient capacity to handle excesses of runoff. It would take several pre-settlement sand-bottomed channels to contain the spring floods that now race to the river over rocky beds.

The adjustment of the watershed of Ramsey Creek to human habitation has taken more than a century. It has cost great quantities of rich soil and human labor. In my own mind I am not convinced that the human race has actually gained as much as it has lost, either in terms of aesthetics or cold economics. In this trade of a sandy creek for a rocky one we have also traded gentle banks for steep ones and constant spring-fed water-courses for a line of murky water-holes. We have given up the deep ponds of the past which furnished clear ice in winter and swimming holes in summer. We have received in their place a shallow stream that flows so weakly in winter that it often freezes solidly, and farmers have to break the ice to water stock. Nowadays many a farmer's boy never learns to swim, and, for that matter, scarcely knows what fishing is unless it be dangling doughballs in front of carp. We have traded a creek which once enriched the lowlands through occasional floods, for one which tears the very soil away from corn roots. What may once have been inadequate drainage is now excessive drainage. Fields which at one time could be easily worked are now dissected by the deep trenches of tributaries. The populations of deer and wild turkey which haunted the wooded creek banks are now replaced by rabbits that graze among the European weeds. Productive river-bottom forests have disappeared in favor of a wasted tangle of roadways, abandoned channels, pieces of fields, and caving, unpredictable banks.

There is a moral to this story, I believe, which might well be taken to heart by a generation which is faced with the complex problems of flood control and river development. Rivers are dynamic, living things which have to act in certain ways. They can provide us with enriched soils, or they can reunite the land with the sea. Ultimately, however, their fate is determined by the treatment which their watersheds and their valley lands receive at the hands of the people who live on them. No program for stream and river development can hope to succeed unless an understanding of this relationship is evident in its plan.

EFFECTS OF DAMMING OZARK SPRINGS

JULIAN A. STEYERMARK

When certain Missouri Ozark streams were threatened by proposed dams in the 1930's the writer began an extensive survey of the flora in the area of the streams involved and made collections of rare and significant plant species. Since that time the Wappapello, Clearwater, Osceola, and Norfolk dams have become an actuality, impounding the waters of parts of the St. Francis, Black, Grand, and North Fork rivers. Gone now are the bottom woods bordering the streams, the wet meadows and marshes of the river valleys, the rich forests at the base of steep bluffs, even the lower ledges of the bluffs themselves (which differ in plant and animal communities from those of the upper ledges). There has been permanent destruction of the habitats and of species along the streams and in several springs. It is believed that these "before and after" surveys are unique for Missouri in revealing actual evidence of the effect of dams on the plant life of the regions affected.

The general public has never been made fully aware of what actually happens to a river or creek when it is dammed, nor does it realize how much of the natural beauty of the stream and its surroundings has been irretrievably lost. Most dams for Missouri are admittedly only for ephemeral use and will not supply a sufficient head of water for sustained economical power generation. As for flood control, reforestation and slope coverage can do far more to restore natural stream conditions than dams can ever do. Ozark streams, fed largely as they are by springs, have a more or less even flow. The waters may rise in the spring and early summer, but they quickly recede and after a few days return to normalcy. They are not a cause of serious floods and have never greatly inconvenienced the inhabitants of the valleys; in fact the farmers even profit from the soils deposited. Ozark rivers, given watershed protection by a sound forestry program, never become a flood menace. Desirable agricultural soils in river valleys should not be sacrificed to the creation of dams.

What bothers the nature lover and biologist most about the damming of Ozark rivers is that it destroys natural habitats for wildlife. Most of the dams would eliminate types of trees and herbs unique in Missouri, types which can thrive only in restricted environments such as rich shaded soil, crevices in certain rocks, or a particular environment which has suited that plant best during the ages. Along the streams at the base of limestone bluffs nature has worked through the centuries to produce rich black soils, the habitat of many plants which can hold their places only as long as man does not interfere with them. Many kinds of plants have found their ecological

Lower Greer Spring outlet. Such scenes as these may become only a memory if dams are constructed.

niches midst the ledges and crevices of the lower parts of the bluffs. These have been growing in Missouri for thousands of years. In fact, many of them are among the oldest of living species, for the Ozarks, like the Appalachian Plateau, have not been covered by intrusions, sea embayments, nor glaciers, since the end of the Paleozoic era, millions of years ago. Neighboring lands to the north, south, west and northeast of the Ozarks do not enjoy such venerable distinction. The Ozarks thus must have served as a focal point for the origin, survival, and migration of many plant species, among them the most ancient in America.

The Grand Canyon, Yellowstone Park, the Big Trees and Redwoods of California, have all been saved because they are spectacular in beauty and interest. But we must also be concerned with smaller and less sensational areas. Dr. Richard Pough has stated recently (*Natural History*, Vol. 56,

p. 432. 1948), that the problem of conservation is "that of securing the preservation of at least one good sample of each of our native American plant communities in their original, undisturbed state. These are the only laboratories in which scientists can work out the answers to the many questions that keep coming up in connection with the management of land originally occupied by a given type. For such purposes their preservation is so essential as to make their setting aside justifiable regardless of what it may cost in dollars and cents to do so." Missourians should be unwilling to lose the heritage which is theirs—Ozark streams as nature designed them.

The most diversified and some of the most valuable timber in Missouri is found, not on the drier uplands, but in the alluvial soil bordering streams. The following list includes some of the forest trees typical of such locations:

White Ash *(Fraxinus americana)*
Green Ash *(Fraxinus pennsylvanica* var. *lanceolata)*
River Birch *(Betula nigra)*
Bitternut *(Carya cordiformis)*
Bladdernut *(Staphylea trifolia)*
Butternut *(Juglans cinerea)*
Cottonwood *(Populus deltoides)*
American Elm *(Ulmus americana)*
Hackberry *(Celtis occidentalis)*
Honey Locust *(Gleditsia triacanthos)*
Hop Hornbeam *(Ostrya virginiana)*
Kingnut *(Carya laciniosa)*
Linden *(Tilia* sp.*)*
Silver Maple *(Acer saccharinum)*
Bur Oak *(Quercus macrocarpa)*
Chinquapin Oak *(Quercus Muhlenbergii)*
Northern Red Oak *(Quercus borealis* var. *maxima)*
Water Oak *(Quercus nigra)*
Pawpaw *(Asimina triloba)*
Sweetgum *(Liquidambar Styraciflua)*
Sycamore *(Platanus occidentalis)*
Black Walnut *(Juglans nigra)*
Willow *(Salix* sp.*)*
Yellow Wood *(Cladrastis lutea)*

Small herbs and showy flowers inhabiting lowland woods or ledges and crevices at the base of bluffs include the following:

Amsonia *(Amsonia illustris* and *A. Tabernaemontana)*
Bellwort *(Uvularia grandiflora)*
Bloodroot *(Sanguinaria canadensis)*
Bluebell *(Mertensia virginica)*
Cardinal Flower *(Lobelia cardinalis)*
Celandine Poppy *(Stylophorum diphyllum)*
Cross Vine *(Bignonia capreolata)*
Dogtooth Violet *(Erythronium americanum* and *E. albidum)*
False Rue Anemone *(Isopyrum biternatum)*
Wild Ginger *(Asarum canadense)*
Iris *(Iris brevicaulis, I. virginica, I. cristata,* etc.*)*
Jack-in-the-Pulpit *(Arisaema triphylla)*
Jacob's Ladder *(Polemonium reptans)*
Lady's Slipper *(Cypripedium* sp.*)*
Orchis *(Orchis spectabilis)*
Phlox *(Phlox amplifolia, P. divaricata, P. glaberrima,* etc.*)*
Pinkroot *(Spigelia grandiflora)*
Spiderwort *(Tradescantia Ernestiana, T. ozarkana, T. subaspera)*
Spring Cress *(Cardamine bulbosa)*
Toothwort *(Dentaria laciniata)*
Touch-me-not *(Impatiens pallida)*
Trillium *(Trillium flexipes, T. recurvatum, T. sessile, T. viridescens)*
Violet *(Viola striata)*
Water Leaf *(Hydrophyllum appendiculatum, H. canadense)*
Water Willow *(Dianthera americana)*

When dams cause the water level of the streams to be raised, thousands of square miles of wild flowers and of forest trees such as those listed above are destroyed. The destruction of the rare species concerns us most, for they are delicately adjusted to very limited environments and can never be restored if once flooded by high dam waters.

No other similar-sized area in the United States contains as many large and clear sparkling springs as do the Ozarks. They have come to be recognized as one of the main beauty spots of America and have attracted hundreds of thousands of visitors from all over the country. Today most of these springs and their surroundings are endangered by a menace of impounded waters. If and when the many proposed dams are constructed on Ozark rivers, not only will the appealing springs be irretrievably lost but the unusual plant and animal life that they sustain will also disappear.

In a number of the underground cave springs exist species of blind crayfish, salamanders, and cave fish, found nowhere else in the United States. In and around the spring branches live unusual species of snails, fish, frogs, insects, and newts, endemic to the Ozarks. If their habitats are destroyed by submergence these rare forms of animal life will become extinct, and along with them evidence of the ways in which animals have adapted themselves to cave and spring conditions.

Because spring waters are relatively shallow and constantly cool they furnish favorable environment to certain kinds of water plants which are found nowhere else in the state. Such rare species are: Ivy-leaved Duckweed *(Lemna trisulca)*, several species of Pondweed *(Potamogeton amplifolius, P. illinoensis,* and *P. pusillus* var. *minor)*, and Water Speedwell *(Veronica connata)*. If the water becomes deeper and warmer from impound-

Wild beauty of Huzzah Creek. Gravel bars, bottom-lands, valley forests, and rich slopes of bluffs are plant habitats which would be drowned out by impounding streams if proposed dams were built.

Bald Cypress along banks of the former St. Francis River. The photograph was taken between Chaonia and Wappapello in 1938, before the Wappapello Dam flooded the area.

ing, these species will die out. Other plants of springs which are facing decimation are White Water Crowfoot *(Ranunculus longirostris)*, Bassweed *(Anacharis occidentalis)*, Burreed *(Sparganium americanum)*, Water Starwort *(Callitriche heterophylla)*, Water Cress *(Roripp a Nasturtium-aquaticum)*, Hornwort *(Ceratophyllum demersum)*, Water Milfoil *(Myriophyllum heterophyllum)*, and Water Purslane *(Ludvigia palustris* var. *americana)*.

Several beautiful springs along the Current River in Shannon and Carter counties, such as Cave, Pulltight, Welch, Round, the famous Blue, and Phillips springs, will all be submerged by the construction of the Grass Creek, Blair Creek, Mill Creek, Phillips Bay, and other proposed dams. Pulltight Spring is the type locality of Spring Cress *(Cardamine bulbosa* f. *fontinalis)*, a plant which is found nowhere else except in the springs of the Ozark region. Submergence of the largest and most beautiful springs in

Virgin Bluff, along James River, Stone Co. All plant habitats at the base of the bluffs and along the stream would be destroyed by the waters of the proposed Table Rock Dam.

The proposed Table Rock Dam would submerge forests and bottom-lands along James, White, and King rivers and their tributaries.

the valleys of the Black, St. Francis, Eleven Points, Gasconade, and Piney rivers, and their various tributaries, will similarly destroy special wildlife habitats. In all, thirty-three of the largest and most scenic of Missouri springs have been scheduled for destruction. The heritage of large blue springs and clear-water streams could never be restored if this comes to pass.

Some species of plants growing in the vicinity of the springs will be flooded out and lost if and when the inclusive dam waters submerge their habitats. Such will be the fate of the southern coastal species of Water Purslane *(Ludvigia macrocarpa)*, an isolated stand of which was found in 1939 around Greer Spring, its only recorded station in Missouri, several hundred miles from its nearest stations to the south (in Louisiana). Greer Spring, second largest in the state and considered by many to be the most beautiful in Missouri, with its waters running through a long narrow canyon, will be flooded if the proposed Bardley Dam is built.

Gone too with the coming of the deeper water will be Water Star Grass *(Heteranthera dubia)*, various pondweeds, Water Willow *(Dianthera ameri-*

Rare swamp plants. The Water Violet *(Hottonia inflata)*, very rare in Missouri, was photographed in 1939, 10 miles southeast of Greenville, Wayne Co. The impounded waters of Wappapello Dam have now destroyed this plant and its habitat.

cana), Yellow Spatter Dock *(Nuphar ozarkana)*, and other water plants characteristic of Ozark streams. Gone likewise will be the shallow-water habitats for fresh-water snails and scuds, clams, various aquatic insects, crayfish, and other crustaceans, and a great host of other wildlife, both macroscopic and microscopic. These serve not only as food for raccoon and other small fur-bearing animals, water birds, and various fish, but play their part in the balance of nature, the furthest ramifications of which no man can tell.

Substitution of new habitats for original ones has so far been discouraging. Witness, for example, the present shore lines of the Lake-of-the-Ozarks (created by Bagnell Dam flooding the Osage and Niangua rivers), or of Norfolk Dam on the North Fork of the White River. Instead of natural sand or gravel bar deposits and flats inhabited by a restricted assemblage of plants and animals, there exist now only flooded bluffs without shores, or else large mud flats covered with some of the commonest and most undesirable weeds. With exposure to the sun and loosening of the rocks and soil from the slopes there comes a dense growth of coarse weeds—Ragweed *(Ambrosia artemisiaefolia* var. *elatior)*, Cocklebur *(Xanthium pennsylvanicum* and *X. chinense)*, Smartweed and Lady's Thumb *(Polygonum punctatum, P. Hydropiper* var. *projectum, P. pennsylvanicum*, and *P. lapathifolium)*, Barnyard Grass *(Echinochloa pungens)*, Foxtail Grass *(Setaria* sp.*)*, Witch Grass *(Panicum capillare* and *P. dichotomiflorum)*, Horse Nettle *(Solanum* sp.*)*, Sow Thistle *(Sonchus* sp.*)*, Beggar Ticks *(Bidens frondosa)*, Beggar's Lice *(Lappula virginiana)*, Eupatorium, and many others. The ugly

black acres of mud left by summer recession of impounded waters remain entirely bare or partly covered by monotonous stands of Smartweed and Cocklebur. Former coves not only become unsightly and uninviting to vacationists and nature-lovers but are unfavorable habitats for plants and animals due to changing water levels and disturbed conditions. Marginal forests are cleared for tourist hotels, for commercial development—and for greater soil erosion. The originally quiet stream becomes a mecca for noisy motor boats. Fishermen flock to waters not suitable for sustained good fishing, since once-shallow gravel bottoms with fast current become silt-covered and sluggish.

Is then the despoliation of natural scenery, the flooding of valuable farm land, the loss of fishing and spawning grounds, and the alteration of natural habitats necessary for preservation of rare species and to further knowledge of relationships between species worth the temporary and doubtful benefits that would be occasioned by ccnstruction of proposed dams on Ozark streams?

FOOD FOR THOUGHT, FOR QUAIL

LOUIS G. BRENNER

At the Arboretum we have seen repeatedly how responsive is the wildlife to management of the land. Wildlife populations are indeed a barometer of the fertility of the soil, the intelligence of our planting efforts, the control of fires and the retention of native habitats. The surprising concentration of animals in this limited area has afforded excellent opportunity for detailed study of critical habits. Unlike in many other localities, one need not wait many days or even weeks between observations at the Arboretum. The daily records consistently available permit an accurate cross-check of the life pattern of an animal and give a true picture of its habits.

Because the development at the Arboretum has favored a large quail population, an excellent opportunity for a close study of the feeding habits of these birds is afforded. The regularity with which the larger covies are seen in certain areas of the Arboretum can be explained by abundance of food there and adequate cover or protection. A close study of such areas reveals the very complex balance of plant growth necessary to supply large quantities of food and maximum protection for the birds, and the common occurrence of several of our native wild plants would suggest their value for food and cover. Stomach contents of birds from other areas have been analyzed and shown to contain quantities of seed of these plants.

The value of native plants as quail food is of course primarily governed by their frequency. Few native quail-food plants are capable of growing

Trailing Wild Bean *(Strophostyles helvola)*, a square meal for a quail.

Prairie Rose (*Rosa setigera*). Our native roses are good quail plants too.

abundantly on poor and eroded soils, and consequently enjoy only a limited distribution today. The very great part they are capable of playing in the reestablishment of heavy quail populations is obscured by statistical analyses of stomach contents of the birds. The great bulk of exotic foods found in stomachs in comparison to the meager quantities of native foods does not necessarily indicate that quail prefer these exotics, but rather should be cause for alarm among sportsmen and biologists that modern agriculture has deprived the quail of the fabulous bulk of native foods once available at the woods-edge and on the prairies of yesterday. The birds, now hungry and starving, have turned to anything to fill their crops. That they are with us today in numbers great enough to offer the sportsman the privilege of occasional shooting is a tribute to the birds' tenacity.

A closer examination of our preferred quail-feeding areas reveals that the plants consistently present were representatives of the pea, rose, and spurge families. It is of course to be expected that the species and their proportionate numbers are determined by the site in question. At the Arboretum, members of the pea family, Leguminosae, appear to be the most important quail-food plants. The various features upon which identification of these plants is based are adequately described in field manuals. However, a brief discussion of those characters which seem to make the plants attractive to quail should prove interesting.

Pea Family *(Leguminosae)*.—

Partridge Pea (Cassia fasciculata).—This is perhaps one of the most valuable of our quail-food plants. Its prolific nature and upright habit provide an abundance of early autumn and winter food, and protection from predators. It is a plant of the uplands where it often occurs in almost pure stands several acres in extent. It seems to be a reliable source of seed under most conditions prevailing in the state.

Virginia Lespedeza *(Lespedeza virginica)*.—This is a rather common and favored quail food. The erect, dense habit of the plant produces adequate cover for the birds while feeding. As is commonly true of many Lespedezas, this species seems well adapted to sites of low fertility and should prove valuable in reseeding depleted ranges.

Trailing Wild Bean *(Strophostyles helvola)*.—As a quail food this plant is of equal importance to the Partridge Pea. Of the three species of the genus found in Missouri, the Trailing Wild Bean is the largest-fruited and most prolific. In old abandoned fields and along wood edges, where the soil is not too depleted, this plant is capable of producing great quantities of seeds beneath the canopy of tangled and twining stems. The two other species of the genus common in this area are the Pink-flowered Wild Bean *(Strophos-*

Sensitive Plant *(Desmanthus illinoensis)*. Quail food in late winter.

styles umbellata) and the Small-flowered Wild Bean *(S. pauciflora)*. They are also potential food plants, possessing qualities similar to those of the Trailing Wild Bean.

Sensitive Plant *(Desmanthus illinoensis)*.—This is another plant requiring a fertile soil. The fact that the seeds are retained much longer in the pods than is common with most members of the Leguminosae make it invaluable as a source of quail food during the winter and early spring.

Rose Family *(Rosaceae)*.—

Members of the Rosaceae have long been regarded as dependable sources of food for all sorts of wild life. The genus Rosa, represented at the Arboretum by the Prairie Rose, *Rosa setigera,* and the Pasture Rose, *R. carolina,* would seem to offer excellent possibilities, particularly if careful selections of hardy and abundant fruiting varieties were made. The bramble formed by many rosaceous plants provides excellent cover.

Glandular Croton *(Croton glandulosa)*. Food from thin ranges.

SPURGE FAMILY *(Euphorbiaceae)*.—

The importance of plants of this family lies in the ability of most of them to thrive on poor soils and to produce great quantities of small, oily seeds. Except on the better sites, they afford only scant cover.

Glandular Croton *(Croton glandulosa)*.—This plant is a rapid-growing annual which seems to have preference for recently disturbed soils, and hence will provide excellent forage on fallowed fields. It will succeed also on sparse ranges where competition from grasses is not too great.

Crown Croton *(Croton capitata)*.—This is a large-seeded Croton valuable for its resistance to drought and its ability to thrive in dry, rocky sites.

Three-seeded Mercury *(Acalypha virginica)*.—The species is a weedy annual producing large quantities of small seeds. It thrives in fallowed or open fields having sparse vegetation cover.

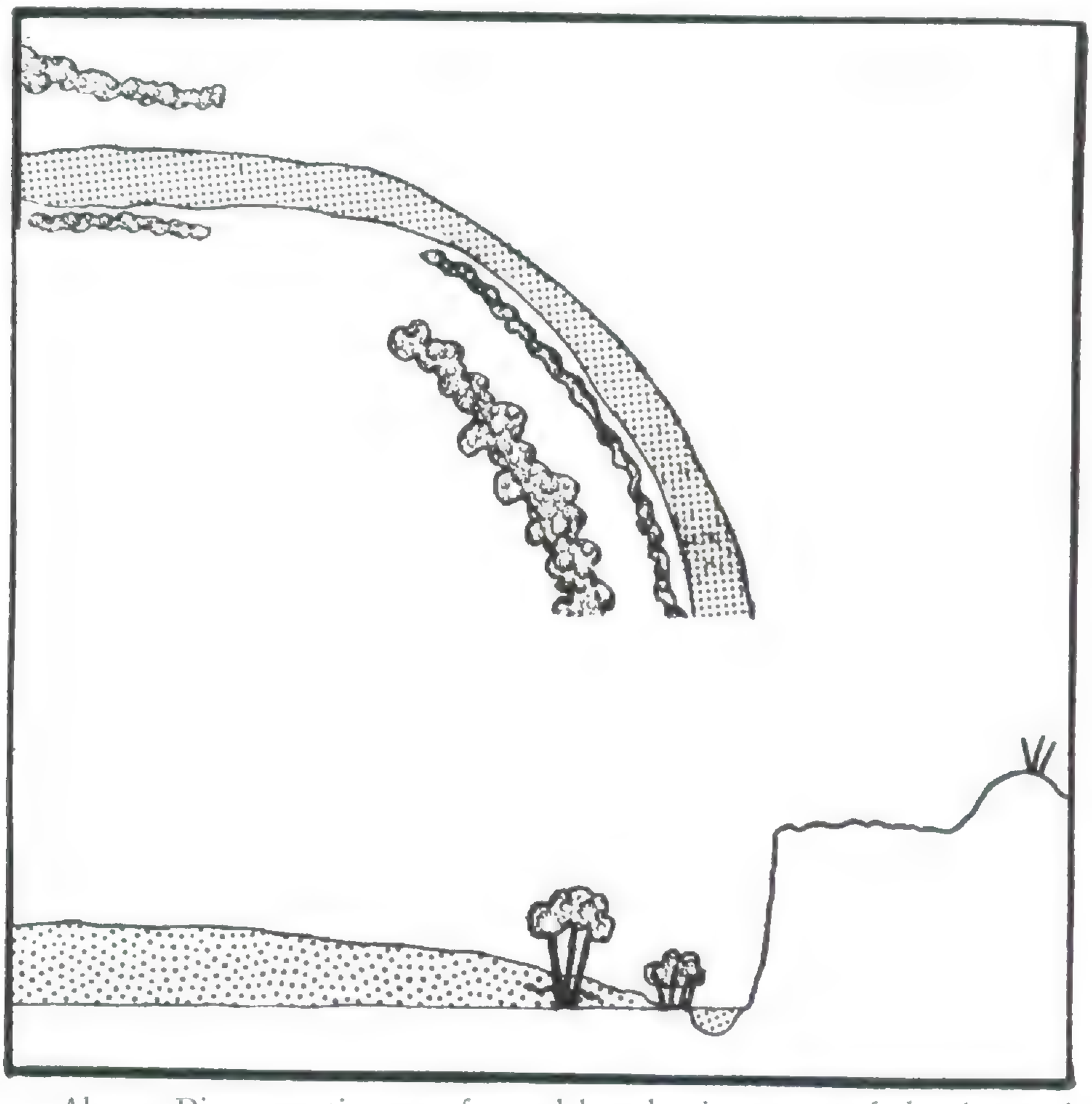
This preliminary list of plants is offered to those interested in developing quail-breeding ranges and shooting areas. It is hoped that continued field work will reveal a more extensive listing. The great numbers of quail resident in the Arboretum, the remarkably large size of the individual covies, and the regularity with which the birds are seen to feed in natural food areas seem to indicate very great importance for the above plants in game management. Through the careful selection of seed sources it is possible that hardy, heavy-fruiting strains, capable of thriving on poor and depleted soils, may be developed.

GRAVEL BARS EVOLVE THEIR OWN FLOOD-CONTROL

EDGAR ANDERSON

One of the most interesting and significant features of the Missouri Botanical Garden Arboretum are the large and constantly changing gravel bars along the Meramec River. It has been appreciated for a long time that at such spots our larger rivers build their own dams and spillways so that they have a natural levee system of their own. At Gray Summit with such a system operating in our own outdoor laboratory, we have been able to work out some of the main principles which make it function the way it does. With a little further study it should be possible to control the river more effectively, using biological as well as purely mechanical restraints.

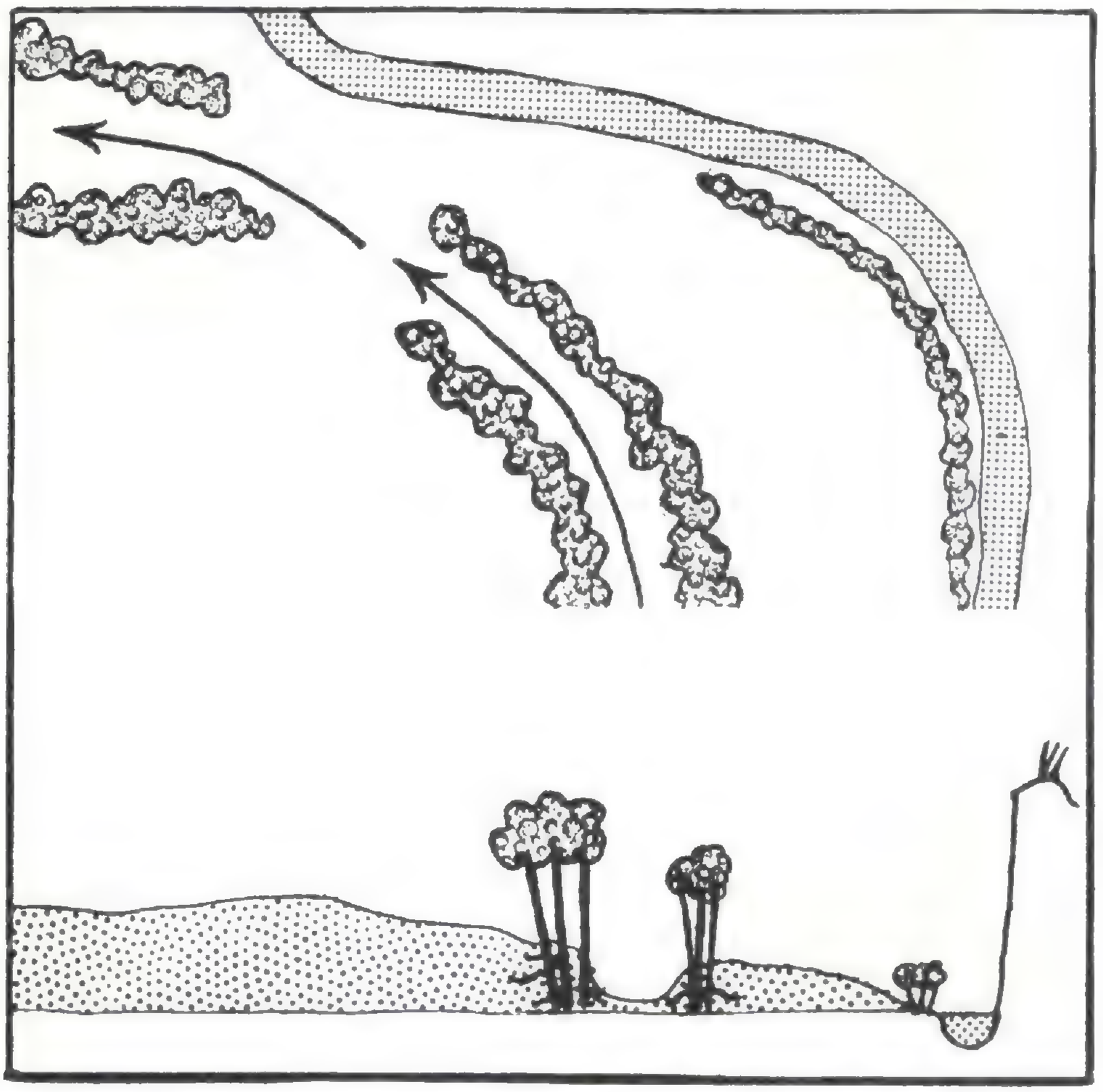
One of the advantages of an arboretum is that it serves as an outdoor laboratory where staff and students may study such problems. As one season follows another the staff not only record the changes which are taking place in the landscape; they think about these changes and discuss them with one another; they study them with their students and attempt to learn not only *what* the changes are but also *why* they occur.



Above: Diagrammatic map of gravel bar showing course of the river and lines of young willows. Below: Cross-section showing gravel, river, and opposite bank.

On the Meramec River, willow bushes are the single most important force in regulating gravel bars and the course of the river around them. Every large gravel bar has willows, most of them in long, narrow rows, the oldest bushes higher than one's head; the youngest, only a few inches high and not yet looking very much like willows to the uninitiated. They are planted in the late spring and early summer, planted by the river when the willow seeds and their parachutes come floating down the river in cottony masses. If it is low water at that time, the seed masses, irregular tufts of dirty cotton batten, come to rest in every cove along the water's edge. Sometimes they make a solid line of cotton for a half mile or more; it is only in those places where the cut banks go straight down into the water that none of them find a lodging place.

If there are no floods for the next few weeks many of the seeds germinate, and by midsummer there will be lines of tiny willows an inch or so high, all along the water's edge. They look weak, ineffectual, and unimportant, yet they are of primary importance in shaping the course of the river. Once established, their little roots hold firm during a flood; and



Same gravel bar several years later. Arrows show natural spillway developed between willow dykes.

they serve as a rallying point for grains of sand and small pebbles being swept along by the current. When the river goes back down to its former level one can see that the seedlings have accumulated quite a mulch of new soil. Even though they are nearly buried by this accumulation they do not mind it at all. They send out new roots from stems above the old ground level and are soon more firmly established than before. Growing with increasing rapidity, they accumulate new soil with every flood, sending their roots out into this natural dyke and soon building a firm structure that may be seven or eight feet above the low-water level and that not even the main current of the river can dislodge.

If the willows fruited well every year, and if there were no June floods to dislodge seeds and young seedlings, then our gravel bars would be covered with parallel arcs of willow dykes, each marking what had been the water's edge the year that it was established. Such regularity of climate is unknown in Missouri. There may be spring floods which cover the bushes at flowering time and destroy the seed crop for that season. There may be later floods which cover the young seed pods and prevent them from ripening off properly. There frequently are June floods which sweep away the seeds before they can become established. More likely than not, several years may elapse between the building of a dyke along the water's edge and the establishment of a new dyke more or less parallel to the old one. Gravel bars in the Meramec are mostly broad stretches of clean, brown gravel, punctuated only occasionally by long, narrow arcs of willows.

Once established, these natural dykes build themselves higher and higher with every flood and tend to encourage the building up of the gravel bar on either side. On nearly every bar one can find a place where two such lines were established in successive seasons or at least within a few years of each other. When the river is in flood these parallel dykes serve as natural spillways and the water races along them at high speed, scouring out the bottom and making the spillway more efficient each time it is used. Few plants can withstand such a rush of water. Along the Meramec River these spillways are frequently paved with almost pure stands of the two species best adapted to such a site, the Ozark Amsonia *(Amsonia illustris)* and *Panicum virgatum*.

The Meramec gravel bars therefore have two main components, the wide open stretches of gravel which were deposited during a succession of years with June floods, and the parallel dykes and spillways from a series of years with low water in the early summer. As the river curves and recurves and tries to change its course, it sometimes cuts across one of the willow dykes, but almost never with any considerable success. Even though it makes a break-through at one point, it is so narrowly hemmed in that at the next

flood time a log jam builds up and the river must take another course. The broad expanses of clear gravel are not so protected, and one never knows when the river may plow back through such areas when its flood tide becomes deflected this way and that.

The whole gravel bar system considered in this way and observed over a series of years seems to be quite a simple and understandable one. If more engineers could be persuaded to unite their understanding of hydrodynamics with an insight into the natural history of gravel bars, we might be able to manage the Meramec River more effectively.

FIFTEEN YEARS OF EROSION CONTROL AT THE ARBORETUM[1]

A. P. BEILMANN

Erosion is a constant threat to an Arboretum, just as it is to farm land and even to the smallest gardens. Soils are carried away by many agencies, but in this vicinity rain causes the spectacular damage which we have come to think of as erosion. Although most people assume that erosion control or soil conservation is a recent development, 2500 years ago Confucius was reported to have advised his listeners not to interfere with seasonal farming nor to let woodsmen operate in the forest except at the proper time. He believed that only with these precautions could the national well-being continue.

The need to protect the top soil, the medium in which most of the foods we require grow, has been understood for a very long time. Terracing, in one form or another, has been practiced by many people from the very beginning of agriculture. However well it might have been understood elsewhere the great advance in soil conservation in this country goes back but a few years. As a nation we have attacked the problem on a huge scale and used much machinery and developed new techniques. Many state and federal agencies have been set up to assist the landowner in conserving soil and to reclaim degraded areas. It will not be amiss, while this subject is attracting such attention, to examine the problem as it applies to an Arboretum and to review the work which has been carried on at Gray Summit.

Terraces were first constructed in the Pinetum in 1929. Terracing is a fundamental method of conserving soil and checking erosion and consists of forming a low ridge of soil at a particular elevation across the slope of a hill. There may be but a few or as many as a dozen such ridges depending on the size of the field and the slope. Terraces tend to divide a field into narrow bands having a relatively gentle slope. These first terraces were

[1] Because it is pertinent to the subject of conservation, this article originally appearing in the May 1944 BULLETIN is here reprinted.

Placing dead branches on the contour to check erosion in wood-lots

rather high and difficult to cross with machinery, but they have served the purpose and none have broken down. Present-day terraces are of a standard type, generally lower and easier to cross with farming tools. Additional terracing was done in 1930, when the apple orchard was planted; altogether some 60 acres were terraced.

Since 1930 other methods of keeping the soil on the hill have been used. One method that has been practiced even more extensively than terracing is mulching. In its simplest form this consists of spreading straw or some such material on a freshly graded slope, either before or after seeding, for the purpose of slowing the runoff of rain. There are many forms of mulching, but here we are interested only in mulching to reduce erosion.

Broadly speaking, landscape grading as usually practiced must be considered a very serious type of erosion. In the ordinary "cut and fill" grading, the high spots are removed to fill the low places. The usual method is simply to begin cutting away the top of the hill and to fill in the hollows, by the use of whatever machinery is available. In an Arboretum there is no more serious and certainly no faster kind of erosion. With modern machinery more soil can be moved in a few hours or a few days than can be eroded by rain in many years. If the top soil is disregarded (and it usually is), then a few hours of grading will do more harm than all the rain which may fall in fifty years. Since 1939 all road grading, and in fact all grading, has been carried on with the thought that top soil must be preserved. To do this, a bull grader is used to shove the top soil in piles near the edge of the area until the necessary cutting and filling is completed. After the lower mineral soil has been moved about to get the proper grade the pile of top soil is brought back and replaced. This procedure has been followed in all road work, and it might be added that the more naturally a road fits into a landscape the more certain it is that much grading was needed. Occasionally both sides of roadside slopes have been covered with straw and hay for a quarter of a mile. In many cases weedy growth from adjoining fields has been used. If such an area is seeded to grass after the original top soil is replaced and then mulched, the first summer will usually heal and remove much of the evidence of fresh grading. While an objection to the cost of removing and replacing the top soil might be raised, the value of this soil is so great that special pains in grading are justified. It is easy to cut down a hill with heavy tractor equipment and fill in an adjoining low spot, but after all the good soil has been removed from the hill it might take half a century to form enough top soil to support plant life.

A rather extensive lot of machinery is required for this kind of work: the usual farm tractor, with plows and discs, as well as graders, rollers,

drags designed for crawler tractor use, etc. No matter what tools are used nor how large or small the area, it is the practice today to remove the top soil before grading and to replace it when the sub-grade is established. Where washing has occurred it has been controlled by driving in stakes to hold the mulch. Sometimes both mulch and sod are used as a filler. Deep roadside ditches have no place in an Arboretum. The same waterway can be provided by making the ditch quite shallow but very wide.

The very best demonstration of the effectiveness of the methods used recently in the Arboretum is shown in the "Story of the Two Bridges." Both are on Brush Creek, which bisects the Arboretum. The upstream (West) bridge is about 2200 feet east of the Robertsville road; the other is 2500 feet downstream. The region west of the property line was normal

Grading finished and shoulders mulched with straw

farm land and subject to the usual erosion, while within the Arboretum area very little erosion occurs. Although these bridges and dams are but 2500 feet apart the amount and kind of water which used to pass were quite different. That part of Brush Creek draining the farm land to the west was typically either entirely dry or a raging flood. At the lower dam, water flows for all of the year except part of the dryer summer. The creek itself, as well as its tributaries, is free from muddy water. The actual volume of water passing the two bridge sites happened to be measured while the bridges were under construction. At the West Bridge a small centrifugal pump, with a capacity of 1500 gallons an hour, was all that was required to keep the excavation dry most of the time. Occasionally as much as 25,000 gallons

per hour were pumped, but this was only during a rain or while the snow was melting. At the East Bridge, a minimum of 30,000 gallons an hour was handled by pumps for weeks at a time and while the snow melted as much as 55,000 gallons were pumped hour after hour for a week. During the time of the peak flow at the East Bridge a four- and a three-inch centrifugal pump were used. Often there was but little water passing the upstream bridge while the rate of flow at the downstream bridge exceeded 30,000 gallons an hour. Essentially the same situations occurred time after time at these bridges after completion. A hard shower caused a very rapid rise in the creek, the muddy water flowed away quickly and the flowage at the West Bridge soon stopped. On the other hand, a week may elapse before such a hard shower reaches the creek at the East Bridge.

The result of water-shed control is clearly seen at either pool behind the dams. Originally 750,000 gallons of water were impounded at the West Bridge and about 500,000 gallons at the East Bridge. The dams were closed on May 22, 1940. In three years they had become useless for water storage. So much silt had been washed into the pools that there was barely eight inches of water left, and this was confined to a stream three or four feet wide. The original lakes were from 45 to 60 feet wide, approximately 250 feet long, and 4½ feet deep. The amount of mud deposited in them was roughly equivalent to one inch of top soil evenly spread over 50 acres. This demonstration of the effectiveness of erosion

Flood in Brush Creek, East Bridge

control can be observed at almost any time, but especially within six hours after a hard downpour. After the flash flood has passed and the muddy water has receded at the West Bridge, a walk along the banks of Brush Creek between the two bridges will disclose only clear water entering the creek from the Arboretum.

Mulches, check dams, and a good plant cover are needed to prevent erosion in the open field. In the woods a different technique is required. Here a thick layer of leaves will prevent erosion, and the first step in obtaining this is fire prevention. While the leaves on the tree and the tree trunks tend to shelter the ground from a beating rain, sufficient rain eventually reaches the ground to cause erosion unless a deep leaf mold is present. The best method of holding the leaves in place is to lay all small dead trees and branches across the slopes, following the practice of making terraces. If many branches are laid across the slope, as shown in the illustration, it might be difficult to walk through the woods. However, the evidence of this work usually disappears within three years because decomposition has taken place and the branches, as well as the leaves, are reduced to plant food. The deep leaf mold acts as a sponge during rainy periods, and the forest floor remains damp long after a similar but unmulched site becomes dry. The effectiveness of this control method has been demonstrated on a number of wooded slopes in the Arboretum. Even during continued rains in the spring no muddy water enters the water-ways and creeks, while on places where fire or cattle or some other agency has prevented the accumulation of leaf mold, the muddy water rushes down the woody slopes.

It is seen that rainfall is a most serious eroding agent, but through the uses of good cover, terraces, and other methods, erosion can be controlled. The exact method to be used in any particular case depends largely on local conditions. Terracing may be required or mulching alone may be satisfactory, or a combination of these, or other methods which have not been touched upon may be the solution. However, heavy rainfall is not the only soil destroyer. Landscape grading is equally effective and is sometimes much faster than any natural agency. But if good gardening is combined with the grading the erosion problem is usually solved. Not enough attention has been devoted to increasing the forest litter and thus holding the rain.

It is certain that the peak flood of any creek or river could be lowered if the watershed were made to retain a maximum amount of rainfall. Reducing runoff from farm land is difficult and not entirely effective, and it seems that more attention to the condition of the woods might be of greater benefit in erosion control. Most rivers in this section have some

scattered timber on the watersheds. If each wood-lot would hold the water a very marked decrease in flood peaks might follow. The two bridges at the Arboretum and the watershed of Brush Creek might be looked upon as a laboratory and serve as a guide toward erosion control. If, in addition to the accepted soil conservation practices, the cover of pastures and open fields were increased and if the wood-lots were manipulated to act as a sponge then top soil should build up annually instead of washing away. The erosion problem in an Arboretum, as well as a farm, begins with the first drop of rain on the highest hill. This drop and those that follow must be absorbed by the ground to prevent erosion and runoff. If fire is kept out of the woods and the litter built up the forest becomes a reservoir. When accepted conservation practices are used to check erosion in an arboretum then it is necessary to revise grading methods. Otherwise the inevitable "cut and fill" becomes the greatest destroyer of top soil.

NOTES

About 200 species and hybrids of orchids are displayed in the 1949 orchid show at the Garden. The plants are arranged in seven shadow-boxes, each box containing a different genus or group.

The 1949 School of Gardening and Nursery Practices, sponsored by the Landscape and Nurserymen's Association of Greater St. Louis, is being held at the Garden from January 25–March 1. Among the lecturers are Dr. Edgar Anderson, Dr. G. A. L. Mehlquist, Mr. G. H. Pring, Mr. A. P. Beilmann, Mr. Paul A. Kohl, and Mr. Lad. Cutak, of the Garden staff.

The recent ice storm caused considerable damage to trees, both at the City Garden and at the Arboretum. Many specimens were bent nearly down to the ground from the weight of the ice, but practically all the hardwood trees have resumed their natural shape without injury. The greatest damage was to the Chinese elms, soft maples, willows, and birches, of which numerous branches broke off under the strain. Fortunately there was no damage to the greenhouse glass.

Recent visitors to the Garden include: Dr. Norma E. Pfeiffer, of Boyce Thompson Institute for Plant Research, Yonkers, N. Y.; Dr. J. E. Howland, Garden Editor *House Beautiful;* Mr. and Mrs. B. B. Hyde, graduate students at Harvard University; Dr. George B. Happ, of Principia College, Elsah, Ill.; Dr. John L. Heller, of University of Minnesota, Minneapolis; Mr. O. W. Norvell, of Stanford University, Calif.; Dr. Charles B. Heiser, of Indiana University; Mr. W. G. McLellan, of E. W. McLellan Co., Orchid Growers, San Francisco.

SOME FACTS ABOUT THE GARDEN

The Missouri Botanical Garden was opened to the public by Mr. Henry Shaw about 1860. From that date until his death in 1889 it was maintained under his personal direction. Although popularly known as "Shaw's Garden" the name Missouri Botanical Garden was chosen by Mr. Shaw and he definitely indicated that he wished it called by that name. The Garden passed at his death into the hands of a Board of Trustees, designated in Mr. Shaw's will, and the Board so constituted, exclusive of certain ex-officio members, is self-perpetuating. By a further provision of the will the immediate direction of the Garden is vested in a Director, appointed by the Board. The Garden receives no support from city or state but is maintained almost exclusively from the estate left by Henry Shaw. Since 1939 many Garden Clubs and interested individuals have contributed to a "Friends of the Garden Fund" which is used in developing the new Arboretum, located at Gray Summit, Mo. The Arboretum (1) serves as a source of plants, trees and shrubs for the city Garden; (2) affords areas for gradually establishing a pinetum, a wild-flower reservation and various other features on a scale not possible in the city; (3) provides greenhouses for some 20,000 orchid plants.

The city Garden comprises 75 acres, where about 12,000 species of plants are grown, both out of doors and under glass. It is open every day in the year except New Year's Day and Christmas; week days, 8:00 a. m. until 7:00 p. m.; Sundays, 10:00 a. m. until 7:00 p. m. The greenhouses are closed every day at 5:00 p. m.

The main entrance to the Garden is at Tower Grove and Flora Place, on the Sarah bus line (No. 42). The Tower Grove bus (No. 21), direct from downtown, passes within three blocks of the main entrance.

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Volume XXXVII March, 1949 Number 3

Cover: Giant Water-platter *(Victoria Cruziana)* in lily-pools at Garden. Photograph by Ladislaus Cutak.

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Missouri Botanical Garden Bulletin

Vol. XXXVII MARCH, 1949 No. 3

WATER-LILIES

GEORGE H. PRING

Since the last general account of water-lily culture (March 1941 BULLETIN) is now out of print and is still in consistent demand, all information on the growing, propagation, and varieties of water-lilies that has been previously published in the BULLETIN has been condensed and brought up to date in this issue. It is felt that the space and expense necessary to epitomize water-lily culture completely and artistically is justified by the interest shown in these plants and by the demand for colored illustrations of the finer commercial varieties developed at the Garden. Persons interested in the lineage and hybridization of tropical water-lilies or other questions beyond the fundamentals here given are referred to previous issues of the BULLETIN which include the following since 1930: Water-lilies (March 1933); Hybrid Nymphaeas (February and March 1934); Amazon Water-lily—*Victoria Cruziana* (March 1934); A New Pygmy Water-lily—*Nymphaea colorata* (June 1940); Tropical Water-lilies (March 1941); The Introduction of the White *Nymphaea gigantea* (February 1947); A New Hardy Pygmy Water-lily—*Nymphaea* "Joanne Pring" (February 1947).

I. WATER-LILY POOLS

Success or failure with water-lilies depends to a great extent upon the pools in which they are to be grown. First consideration in locating a pool should be given to the amount of sunlight available. Full sun is essential for water-lily culture. The depth of the pool will depend upon whether the lilies are to be grown in boxes or in a natural soil bed.

It is not necessary to provide a continuous supply of fresh water for a lily pool. In fact, the tropical lilies do best in water of a warm and even temperature, and if the pool has a concrete or gravel bottom and is stocked with fish, snails, etc. the water will keep pure and clear. Only enough fresh water need be added from time to time to replace that lost by evaporation. The fish supply in the pool is important in order to keep down the mosquito larvae.

Main Greenhouse and Tropical Lily Pools

A water-lily pool may become discolored and weed control may be difficult if the bottom is completely soil-covered. For this reason many gardeners prefer to raise their lilies in large boxes or half barrels, setting these containers on the pool floor.

Planting.—If the pool is large, a plan drawn to scale will save considerable time in planting out and insure color harmony. One water-lily to each spot or container is the rule. Two lilies planted together will give an unbalanced effect through interference with natural radial growth. The plants should be kept in their pots and immersed in water until planted, otherwise most of the moist soil will fall away from the roots by the time the lilies are carried through the pool to the planting spots. Before planting, a hole equal to the size of the pot should be scooped out. The plant is removed by holding the inverted pot with the left hand and tapping the base with the right palm.

Summer Care.—During the summer, in addition to controlling the few pests which may attack lilies, all discolored leaves, faded flowers, and seed-pods should be removed. To remove all floating leaves and debris from the pond a handy gadget may be made by stretching a copper-screen wire across a frame about 1 x 1½ feet and attaching it to a 6-foot handle. With this one can readily skim the pool's surface, keeping it clear to reflect the sky and outline the leaf pattern of the lilies.

Maintenance of the Pool.—Before water-lilies attain sufficient growth to shade the pool, algae can become an unsightly pest. If the pool is large and has no fish, copper sulphate may be used to kill the algae, the copper sulphate being placed in a cheese cloth bag suspended from the end of a stick and dragged slowly through the pool until the water turns slightly blue. Lilies may be set out a day or two afterwards, but fish should not be put in the treated water for at least a week. For a small pool, or one which is already stocked with fish, permanganate of potash is a safer means of control, but its effect is not as lasting. About one teaspoonful of a saturated solution of this chemical to a gallon of water will be effective. It may be used not only before the lilies are planted but at any time during the growing season, although it will doubtless harm very young fish.

A pest of natural pools is the crawfish. Crawfish may cause leaks in the banks, or they may pinch off young leaves before these have reached the water surface. One pound of tobacco dust broadcast to each 100 cubic feet of water at first sign of warm weather may save much trouble later on. If this pre-treatment has been neglected the crawfish may be controlled, although less effectively, by a poisonous bait such as Paris green on chopped meat placed at the edge of the pool.

Planting out in the spring.

Removing old leaves during the summer.

Digging up tubers in the fall.

Showing growth and roots of a single specimen planted out May 15 from a 4-inch pot.

PLANTING TROPICAL NYMPHAEAS OUTSIDE

Natural-bottom ponds are subject to trouble from aquatic weeds, such as Aponogeton, Sagittaria, Typha, Callitriche, etc. To keep these weeds in check the bottom of the pools should be scarified once a week.

Relatively few insects attack water-lilies. Large insects may be picked by hand easily. Aphis may be removed by a forceful water spray and will furnish live food for the fish. Insecticides may kill the fish, but if no fish are present, nicotine sulphate may be used to control aphis. The leaf miner (*Chironomus modestus*) sometimes tunnels its way under the epidermis of the leaves, causing yellow, irregular lines. Where growth of plants is rapid this insect may be controlled by cutting off the leaves and burning them. If there are no fish dry powdered arsenate of lead may be dusted over the leaf surface with a powder bellows. Dusts rather than liquid sprays are recommended for lilies, since a better spread is obtained, particularly if the leaves are moist.

The delta moth, *Hydrocampa proprialis*, is very active in St. Louis from July on. Its eggs are laid on the under-side of the young leaf. The larva cuts two triangular pieces varying from ½ to 1 inch from the leaf edges and fastens itself between them by a web. Completely hidden, it travels in its triangular boat or raft over the water surface to other plants. However, as the rapidly growing lilies need weekly removal of leaves at this time the pest causes no great damage.

Young tropical water-lilies, particularly the night bloomers with colored leaves, may be attacked by the larvae of the family Chironomidae. It is not until the ruined leaves are cut off and allowed to dry that the larvae may be observed as colorless, thread-like worms about ¼ inch long. Should these pests become serious, the only treatment is to remove the fish from the pool and sprinkle tobacco dust at the rate of one pound to each 100 cubic feet of water.

The leaf beetle is troublesome in some parts of the country. It measures ¼ inch in length, and lays its bright yellow eggs on the surface of the leaves. The elongate larvae are bluish black above, and yellow on the under-side, about ⅜ of an inch in length, tapering toward each extremity. They feed both upon flowers and the upper leaf-surfaces, and are particularly damaging to the upturned edges of the Victorias. Remove fish before using a control, which consists of 1 part Paris green to 50 parts of air-slaked lime, applied by powder bellows.

Botis nelumbialis attacks the lotus (Nelumbium) and is readily observed when it rolls and gums itself between the edges of the young leaves. It is a voracious feeder, but it may be controlled by hand-picking and burning. The alternate control, arsenical spray or DDT dust, is, of course, fatal to fish.

About the only fungus known to bother lilies to any extent is a Cerco-

spora, which discolors the leaves in irregular or circular spots and frequently causes the edges to dry and turn up. Since the fungus spreads rapidly these discolored leaves should be immediately removed and burned to prevent spore distribution. Where necessary, and if no fish are present, the plants may be sprayed with Bordeaux mixture, using half the usually recommended strength.

II. Growing and Selection of Hardy Water-lilies

From the figures of water-lilies on the monuments and tombs of ancient Egypt it seems rather certain that the Egyptian Lotus was not a true Lotus (of the genus Nelumbo) but a water-lily (genus Nymphaea). Of the two kinds pictured, one appears to be a white night-blooming Nymphaea *(N. Lotus)*, the other a blue day-blooming lily *(N. caerulea)*, the former occurring much more frequently. Little improvement was made over Nature in the development of water-lilies until the nineteenth century. In 1850 Paxton, gardener to the Duke of Devonshire, created the first hybrid Nymphaea, *Nymphaea devoniensis*, and during 1888-1890 the French hybridist, Latour Marliac, produced the yellow and pink hardy Nymphaeas which are still unsurpassed in that class. Since 1912 the breeding of tropical day-blooming lilies has been actively carried on at the Garden, the climate of St. Louis being admirably adapted for growing them. The first pure white variety Mrs. George H. Pring was a Garden hybrid. Of unusual interest to water-lily breeders was the discovery in Africa of a new yellow lily, *Nymphaea Burttii*. Using this species as a parent, outstanding varieties of lilies have been created at the Garden in shades of yellow, peach, rose, etc. A complete list of these Garden lilies with concise descriptions is given on pages 81–83.

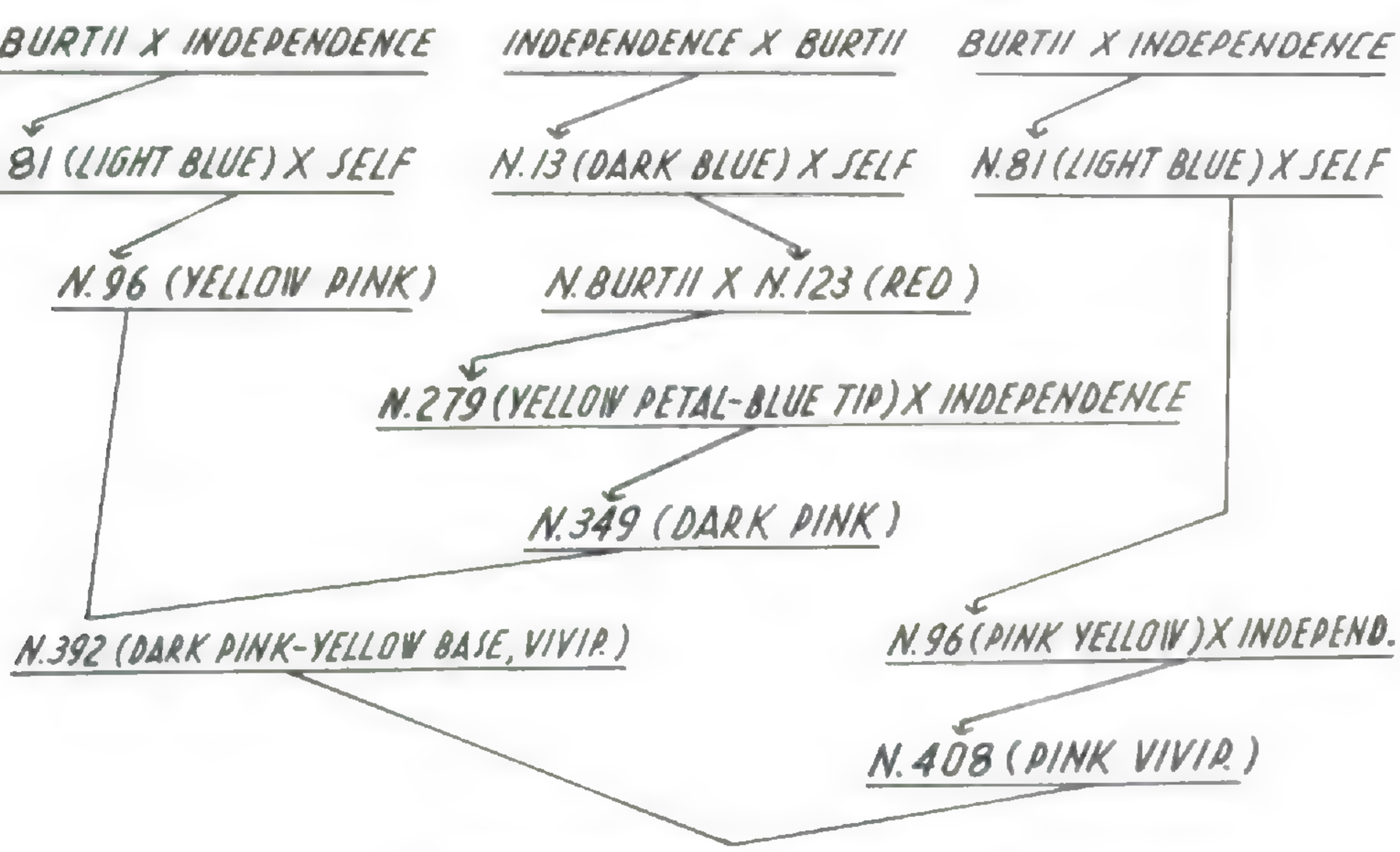


Chart showing parentage of tropical *Nymphaea* Talisman

Storing young tubers in the winter

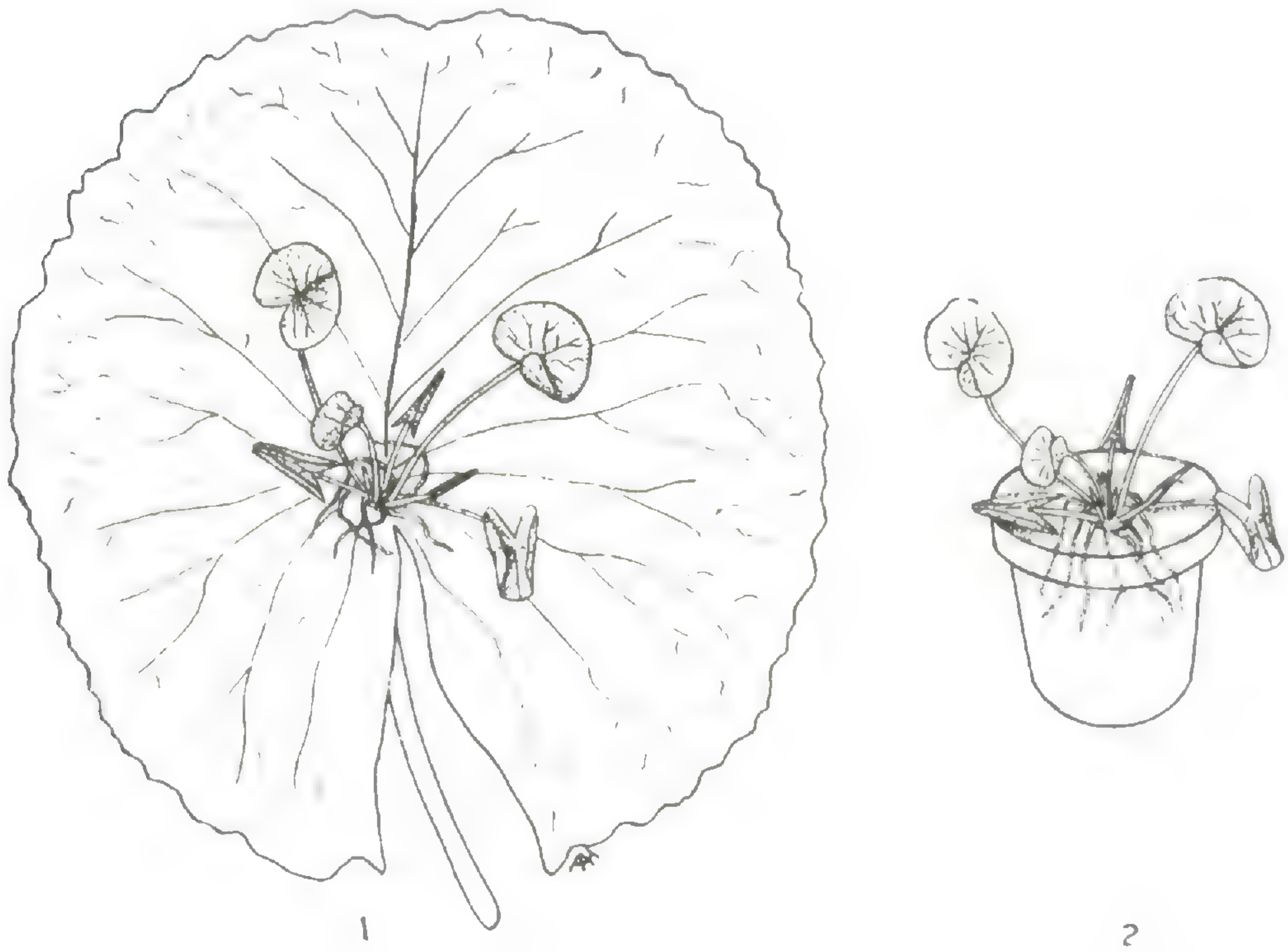
Potting tubers for propagation.

Removing young growth in the spring, leaving tuber for subsequent growth.

Showing young growth attached to propagating tubers.

GREENHOUSE PROPAGATION OF TROPICAL NYMPHAEAS

Left, small propagating tuber kept dormant in sand for three years; right, parent tuber showing young tuber forming at base.



1. Showing production of young viviparous plants from center of leaf.
2. Young plants removed and potted.

1. TROPICAL NYMPHAEAS.—

Planting.—These are large plants and need about one foot of water above them for proper development and at least a foot of soil in which to grow. If they are to be planted in boxes, a bushel of soil should be allowed to each plant; if planted directly in pools a foot of soil above any impervious bottom will suffice. Since the mature leaves of tropical lilies measure from 12 to 18 inches across and as many as 18 leaves often radiate from the center of a plant, the plants need a spread of 6–8 feet. Unless this much space is allowed, the new leaves will be crowded out of the water and the flowers will be disfigured.

The shipped plants should be unpacked immediately upon receipt and placed in water until they can be permanently planted. A bamboo stake at the planting spot in the pool will indicate the location of the dormant tuber should it "go to sleep" unexpectedly. It may be removed after the plant is established. The lilies should be kept in their pots until the planting spot is reached. The unbroken ball is then placed in the hole and firmed down, with the crown of the lily slightly above ground level. The soil surface should be covered with sand or gravel to prevent disturbance by fish, but the crown of the plant must remain uncovered.

Nymphaea leaves sometimes remain submerged after planting but the next day they will extend their petioles and reach the surface. Not more than one foot of water should be allowed above the crown at planting time. If the pool is so deep that a higher level is necessary, water may gradually be added as the plants develop, but 18 inches above the plant is the greatest water depth permissible.

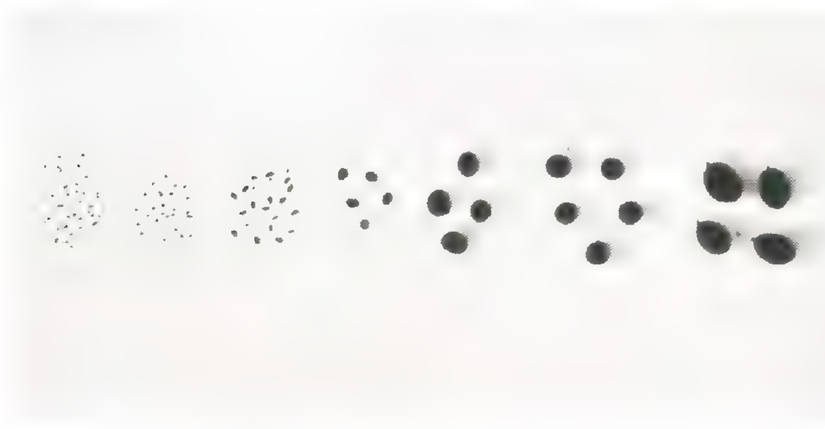
The time to plant tropical water-lilies outside will depend upon the climate. A temperature lower than 70° F. makes the plants dormant, from which they are slow to recover. In the Midwest, they can usually be planted by the middle of May, earlier in the South, and in the East and the Great Lakes regions the first of June is more likely to provide the necessary 70° F. minimum, both day and night.

Propagation by Tubers.—Since the propagation of tropical Nymphaeas demands full sunlight and heated water over the winter, most amateurs prefer to buy fresh plants each spring. However, it is possible to raise tropical lilies in an aquarium if the necessary constant heat is provided by electrical coils or some similar device. Propagation of tropical lilies from seed is definitely not recommended for the amateur.

After the first frost, the water-lily plant should be dug up and washed. It is almost impossible to store the large tuber satisfactorily over winter, but at the base of most of them will be found a tiny tuber, about the size of a walnut. Night-bloomers and hybrids of *Nymphaea colorata* origin bear baby tubers at the top of the old bulb as well as at the bottom. These small

Showing vertical stamens on first day (left) and inflexed stamens after first day (right).

Top, seed-pods of tropical day-bloomers, fertile, (left), sterile (right); bottom, fertile seed-pods of night-bloomers.



Types of water-lily seeds. Left to right: tropical day-bloomer, night-bloomer, *Nymphaea gigantea* (Australian), hardy, *Euryale ferox, Victoria regia,* and Nelumbium.

Showing variability of seed pods. Left to right: *Nymphaea tetragona,* hardy, tropical day-bloomer, tropical night-bloomer, and *Victoria Cruziana.*

Nymphaea gigantea ALBERT DE LESTANG, from Australia

tubers should be removed and stored in slightly moist sand, in closed containers, until early spring. Then they are potted about two inches deep in sandy soil. The pots should be placed in water at a temperature of 70° F. or warmer, in a sunny window. The young leaves ordinarily appear in about two weeks. As soon as the floating leaves have developed, locate with your thumb and forefinger the stem-like growth connecting the young plant to the tuber. Follow this stoloniferous growth down and carefully pinch it off just above the tuber, removing the young plant with its attached roots but leaving the propagating tuber in the pot. The young plant should be immediately potted to prevent its drying out, and then placed in the heated tank in which the propagating stock is growing. In two weeks the original propagating tuber will send up another plant, which can also be removed and potted. This process may be repeated three or four times before the tuber is allowed to retain the last plant. The tank will then be filled with infant water-lilies capable of producing flowers of the same quality and variety as the original plant.

Before potting young plants which have been segregated from the tubers, the roots are separated so as to permit sifting of the soil between them. The crown is left slightly above the soil and sand covering. The plants may be started in 3- to 5-inch pots, depending on their size, a 5-inch pot usually being large enough to carry a well-rooted lily through until planted outside. When transplanting into a larger pot, the ball of soil should not be pressed too hard, for the wet ball might bulge above the new potting soil and break the tender young roots. The crown should always be kept above the soil and covered with ¼ inch clean sand to prevent the soil leaching out when the pots are placed under water. A ¼-inch space left below the pot rim will allow for the soil expansion when submerged. Otherwise pushed-out soil will soon cover the bottom of the tank.

Propagation of Viviparous Plants.—The viviparous group (those in which the young plants sprout from the parent leaves) of tropical water-lilies includes a great many fine types. As the young plants in the leaf sinuses (space between the leaf lobes) develop roots during the growing season, they should be removed from the leaves for potting. The pots may be stood up on bricks in a corner of the lily pond until cool weather necessitates removal to the indoor heated tanks. There they will not only grow but will probably bloom a bit the first winter. Not all the plants listed as viviparous in the list on pages 81–83 are viviparous in other localities. Due to the difference in the length of the season there are fewer such varieties in the East and North and more and stronger ones in the South.

The usual multiple-headed plants raised from plantlets in the leaves will have smaller flowers than the single-headed forms raised from tubers. Not much can be done to reduce a multiple-headed plant once it has been set out in the pools, but practically all viviparous lilies can be divided readily into single plants while they are still in the formative period. The young lily must be removed from the pot when the individual growths, with a central shoot to each one, are readily discernible. With a sharp knife cut through the thickened tissue where the new tuber is forming to obtain several tiny plants with attached roots. These can then be grown in the usual fashion, and, instead of one large plant with small flowers, several plants with large blooms and a better leaf pattern will develop.

Propagation from Seeds.—Some water-lily fanciers may want to raise tropical lilies from seed. Most seedlings will have to be discarded, either for lack of room, or, once they have bloomed, because of their inferior flowers. The flower to be chosen for seed-bearing must be protected from insect pollination to insure a pure cross, and must also be emasculated in the bud stage to avoid contamination from its own pollen. The first day that the cup-shaped center is filled with nectar is the time for pollination. At the

Nymphaea Burttii, the pollen parent, MRS. GEORGE H. PRING, the seed parent, and ST. LOUIS, the offspring.

same time, anthers containing pollen from the chosen male flower should be removed and placed on the pistil of the selected seed parent. In order to exclude foreign pollen and to prevent premature dissemination of seed, a cheese-cloth bag should be tied over every bloom intended to be harvested. It is also helpful to tie a long string to the flower stem, attaching the other end to a stake near the crown of the plant, so that the pod can be readily pulled up for an occasional inspection.

After pollination, the fertilized bud closes up tightly and makes a deep nose-dive under the water's surface, thus preventing the drying out of the fertile seed. A flower which has merely completed its growth without being fertilized will not dive. When the pod is ripe (usually about three weeks after pollination), it rises to the surface, and unless the cheese-cloth covering has been attached with care, the seeds will be scattered over the pond. The ripe seeds should be removed and placed in a jar of water to allow the fleshy covering to disintegrate. Virile seeds, when fully ripe, sink to the bottom of the jar in a week or so, and should then be removed to prevent premature

Nymphaea JAMES GURNEY, a night-bloomer

Nymphaea colorata, a small African lily

germination. When the seeds are dry and separate readily, they may be sown at once in sandy soil covered with water.

If large tanks are available, the seeds may be sown in shallow pans and the pans immersed in the tanks. The water must be kept at an even temperature of 75–80° F. Once the first floating leaves are developed, the plants may be potted and kept at the same temperature in full sunlight during the winter. It is sometimes found more convenient to sow the seeds in small containers, such as a glass jar, to hold both the necessary two inches of soil and the water covering. For a larger crop, a pottery crock or even a half barrel might be used, enough seedlings being removed for summer bloom in the pools. The remainder may be left in the container which is placed in the pool for tuber formation by fall. The tubers may in turn be stored in moist sand for the following year's stock.

Varieties of Tropical Nymphaeas.—It is manifestly impossible to list here all the named varieties of tropical water-lilies in the trade to-day, and the reader is referred to catalogues of firms specializing in water-lilies, such as Tricker's, of Saddle River, N. J., or to the book "Goldfish Varieties and Water Gardens" by W. T. Innis, published in 1947. The moderately long hot summers in St. Louis permit relatively long blooming seasons and adequate opportunity for breeding tropical lilies. All the varieties listed on the following pages were either developed or introduced by G. H. Pring, except some of the night-blooming kinds which were originated at Tower Grove Park. The dates at the end of the descriptions refer to the year in which the lilies were described in the Garden BULLETIN.

DIRECTOR GEORGE T. MOORE

Mrs. George H. Pring

American Beauty

Peach Blow

African Gold

Mrs. George C. Hitchcock

General Pershing

DAY-BLOOMING VARIETIES OF TROPICAL NYMPHAEAS

BLUE

BAGDAD.—Flowers broad, flat, borne close above the leaves, the many petals Wistaria Blue,[1] the stamens golden; buds purple striped. Leaves medium, light green marked with reddish brown splotches above, purple striped beneath. Strongly viviparous. (1941).

BOB TRICKETT.—Flower large (10–14 inches across), Campanula Blue with yellow center, similar to MRS. EDWARDS WHITAKER but more cup-shaped and fuller; buds green. Leaves large, orbicular, green above, red with green veins beneath, the margins undulate. Not viviparous. (1948).

CELESTE.—Flowers striking, Wistaria Violet, the petals clean-cut, the stamens a brilliant golden yellow; buds purple striped. Leaves moderately large, dark green flecked reddish brown above, light green and purple spotted beneath. Occasionally viviparous. (1941).

Nymphaea colorata.—African species, introduced in 1938. Flowers comparatively small with broad, purple to lilac petals. Leaves very abundant, rather small and forming a pleasing pattern; adaptable to limited space. Not viviparous.

DIRECTOR GEORGE T. MOORE.—Flowers compact, moderately small but larger than in *N. colorata*, a deep rich purple with a golden center; buds green. Leaves smallish, dark green, occasionally flecked with purplish brown, the underside light green flushed with purple; forms excellent rosette pattern. A profuse bloomer and propagates freely from tubers. (1941).

Nymphaea gigantea "ALBERT-DE-LESTANG".—Flowers like *gigantea alba* except flushed blue the first day, the stamens with a purplish red ring at the base. Leaves like *gigantea alba*. Not viviparous. (1946).

HENRY SHAW.—Flowers wide-opening, spreading, fragrant, Campanula Blue, with Chrome Yellow stamens. Leaves sparsely splotched with light brown above, flushed pinkish red below. Not viviparous. (1947).

JUDGE HITCHCOCK.—Flowers cup-like, moderately large (8 inches), full, Bradley's Violet towards the margin merging to Wistaria Violet, the stamens golden but blue-tipped; buds green. Leaves smallish, dark green flecked reddish brown, purplish beneath. Propagates well from tubers but not viviparous. (1941).

MIDNIGHT.—Flowers abundant, small, with few large petals and many smaller stamen-like petals towards the center, a deep rich purple with only a small golden center; buds dark green. Leaves smallish, dark green, sparsely flecked with reddish brown, purple beneath. Not viviparous. (1941).

MRS. EDWARDS WHITAKER MARMORATA.—Flowers rather large, reaching 8 inches or more in diameter, with numerous thin, lavender-blue petals. Leaves streaked and mottled with Chestnut Brown. Not viviparous. (1947).

MRS. WOODROW WILSON GIGANTEA.—Flowers medium-large, pale blue, highly fragrant; buds dark green, purple-striped. Leaves smallish, dark green spotted with brown above, flushed brownish pink beneath. (1917).

PINK

AMERICAN BEAUTY (see color plate).—Flowers reddish (light Mallow Purple of Ridgway), moderately large (6–10 inches), Lemon Chrome at the center. Leaves large, orbicular, bright green, brilliant red with green veins beneath, wavy margined. Not viviparous. (1941).

CASTALIIFLORA.—Flowers large, pink with yellow stamens. Leaves delicately mottled with red, indented at the margins. Not viviparous. (1941).

EDWARD C. ELIOT.—Flowers pale pink, shallow cup-like, the petals pointed; buds dark green spotted purple. Leaves green, flecked reddish brown, pink below. Not viviparous. (1924).

GENERAL PERSHING.—Flowers large, pink, usually 8–10 inches in diameter, full, fragrant, persistently open, borne about a foot above water-level; buds dark green striped purple. Leaves large, streaked reddish. Not viviparous. (1917).

PEACH BLOW (color plate).—Large, full, rounded flowers with many petals and stamens, deep pink (pale Persian Lilac of Ridgway), lighter towards the center; buds green. Leaves moderately large, light green, sparsely flecked, fading in age, light green flushed réd beneath. Freely viviparous. (1941).

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[1] Color terms are based on Ridgway's Color Standards and Color Nomenclature.

PERSIAN LILAC.—Flowers moderately large, pink (Ridgway calls the color Persian Lilac), full, rounded with broad petals, the golden stamens tipped pink; buds green. Leaves smallish, light green sparsely flecked brownish, red beneath. Not viviparous. (1934).

PINK PLATTER.—Flower large, wide, flat, moderately full, the petals long and narrow, the stamens golden below, pink above; buds green. Leaves moderately large, light green prominently flecked reddish brown, underside light green flushed red. Viviparous. (1934).

RIO RITA.—Flowers moderately large, a deep brilliant pink, almost red (Amaranth Pink and Tyrian Pink of Ridgway), opening wide, the petals broader than PINK PLATTER, base of the stamens bright golden; buds green. Leaves smallish, dark green sparsely flecked reddish brown, red beneath. Weakly viviparous. (1934).

SHELL PINK.—Flowers clearer pink than GENERAL PERSHING, large and firm, bowl-shaped; buds clear green. Leaves moderately large, dark green flecked with reddish brown, reddish on the underside. Sparingly viviparous. (1941).

TALISMAN.—Flowers large, star-shaped, less full than PEACH BLOW, with the blending and suffusion of color characteristic of a Talisman Rose (Primrose Yellow flushed with bright pink); buds green. Leaves smallish, dark green flecked with purplish brown when young, fading in age, reddish beneath. Highly viviparous. (1941).

WILD ROSE.—Flowers bright, solid, large-petaled, Rosolane Pink with a large golden center, the stamens pink-tipped; buds green. Leaves moderate, dark green flecked reddish brown, light green flushed red below. Viviparous. (1941).

YELLOW

AFRICAN GOLD (color plate).—Flower smaller than ST. LOUIS but of a deeper yellow, well-formed, full; buds light green. Leaves smallish, light green, the underside pale. Non-viviparous. (1941).

Nymphaea Burttii.—Introduced from Africa in 1930. Flowers small to moderate, Primrose Yellow, shallow, the petals tapered; buds light green. Leaves spotted reddish brown, the mottling fading in age, light green beneath. Not viviparous.

ST. LOUIS.—Flowers very large, 10 inches in diameter, star-like, fuller than YELLOW STAR, pale Viridine Yellow. Leaves pea-green faintly spotted with reddish brown when young, paler below. Not viviparous. (1932).

SUNBEAM.—Flowers open, similar to ST. LOUIS but somewhat smaller, in age becoming a darker and richer yellow; buds striped purple. Leaves moderate, light green flushed purple, reddish on the underside. Viviparous. (1941).

YELLOW STAR.—Flowers large, shallow, star-like, Viridine Yellow, borne well above the water level, with relatively few, long, tapered petals. Leaves large. An excellent lily for mass display. Not viviparous. (1922).

WHITE

DAISY.—Flowers large, shallow, white with golden center, the stamens tinged pink in cool weather. Leaves dark green splashed with brown, light green beneath. Viviparous. (1934).

Nymphaea gigantea alba.—Flowers large, peony-shaped, fragrant, held well above water level; the club-shaped stamens Cadmium Yellow. Leaves pale green above and below, the margins indented. Not viviparous. (1947).

ISABELLE PRING.—Flowers similar to MRS. GEORGE H. PRING but fuller and more rounded, fragrant; buds light green. Leaves very large, light green above, flecked reddish brown below but this fading in age. Strongly viviparous. (1941).

Nymphaea ovalifolia.—Species introduced from Africa in 1914. Flowers star-shaped, white, the petals tipped pale blue, few and the flowers thus not full, stamens yellow. Leaves oval, light green above, slightly flecked with Copper Brown, flushed bluish below. Not viviparous.

MRS. GEORGE H. PRING.—Flowers numerous, pure white except for the yellow stamens, very large (up to 13 inches), shallow, thin, fragrant. Leaves very large, faintly mottled with reddish brown, lighter green suffused with pink beneath. Adapts well to pool size, with correspondingly large or small flowers. Not viviparous. (1922).

NIGHT-BLOOMING VARIETIES OF TROPICAL NYMPHAEAS

RED

B. C. Berry.—A Tower Grove Park hybrid, similar to James Gurney. Flowers shallow, large (8–9 inches), Amaranth Purple, lighter towards the base of the petals. Leaves moderate, dark green, scarcely mottled, indented on the margins. Not viviparous.* (1922).

Frank Trelease.—Flowers a glowing dark crimson, but unfortunately not abundant, shallow, the petals long, narrow, rounded. Leaves dark Copper Brown, occasionally flecked green. Tower Grove Park hybrid. (1922).

H. C. Haarstick.—Flower very large (10–12 inches diameter), similar to Frank Trelease but perhaps fuller and lighter-colored, exceedingly striking. Leaves very large, unusual in their copper coloration, the margins indented. Perhaps the best red water-lily. Tower Grove Park hybrid. (1922).

PINK

Emily Grant Hutchings.—Flowers very large, cup-shaped, pinkish-red. Leaves small, brownish green. Tower Grove Park hybrid. (1922).

James Gurney.—Flowers fragrant, large, 10–12 inches across, deep Rose Pink, shallow, with elongate petals, borne well above the water line. Leaves very large, orbicular, Copper Green, purplish brown beneath, fluted on the margins. Tower Grove Park hybrid. (1948).

Mrs. George C. Hitchcock (color plate).—Flowers large, Rose Pink, stamens deep orange. Leaves copperish green flecked with green, purplish brown beneath, margins undulate. (1926).

WHITE

Missouri.—Flowers very large (up to 14 inches), pure white, full, with many broad petals and erect stamens. Leaves large, mottled, indented on the margins. A truly outstanding night bloomer. (1932).

2. HARDY NYMPHAEAS.—

Nothing remarkable has been accomplished at the Garden with hardy lilies, most attention having been centered on the tropical day-bloomers. However, hardy lilies are particularly suitable to the small pool, since they have smaller leaves and smaller spread than the tropical lilies and an earlier blooming season—from May to July. Unlike the tropical lilies also, the flowers are never in shades of blue or purple, and they "float" on the surface of the pool, not being thrust above the water surface on strong pedicels.

Most of the cultural directions given for the tropical Nymphaeas, aside from propagation, apply also to the hardy types. Hardy types require less space than do the tropical ones, and they may be left *in situ* for a few years provided they are not allowed to freeze in winter. If planted in boxes or tubs in the pools the containers should be lowered in winter below the ground level at which freezing might occur; or the pool could be covered over with boards and a layer of leaves, straw, etc., to prevent freezing and killing of the rhizomes. With proper winter protection hardy lilies will remain viable for years.

For best results hardy Nymphaeas should be lifted and reset in new soil every two to three years, at which time they can be propagated by separating the underground stems (rhizomes) much as potatoes are planted with an "eye" (axillary bud) to each segment. Hardy lilies are sold by the rhizome

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*None of the night-bloomers are viviparous.

in contrast to the tropical kinds which are usually marketed as small plants in pots (or suitably wrapped for handling or shipping). Except for breeding new varieties they are propagated vegetatively. A large number of hardy varieties can be purchased from dealers in aquatic plants, or from amateurs

Pygmy Nymphaea JOANNE PRING

who find themselves with too many plants after several years of growing and separating them in the home pool. The named varieties which have proved outstanding at the Garden include: White—GONNERE; Yellow and Yellow-red—SUNRISE, COMANCHE; Red—ATTRACTION, JAMES BRYDON.

Pygmy Types of Hardy Lilies.—The pygmy water-lilies are well named. Their delicate little flowers are seldom more than two inches wide, yet so perfectly are they proportioned that at first sight they give the impression of something created for a toy village. They are an excellent subject for a small pool where larger lilies would be quite out of scale. Size is not their only recommendation, however, for most of the "pygmies" are perfectly hardy and flower freely from late spring until the first heavy frost. All of them are suited to tub culture.

Three colors are commonly grown—the white, the yellow, and the pink. The white is *Nymphaea tetragona*, a species native to a good part of the

northern hemisphere, in Eurasia from eastern Russia to Japan, and in the New World in Idaho and Canada. The specific name refers to its form, after the size its most distinctive feature, (*tetra* meaning "four," and *gona* meaning "corner"). The whole flower is very strongly four-sided and is often so mathematically regular that it looks quite artificial. The yellow pygmy is the result of hybridization between *Nymphaea tetragona* and the yellow *Nymphaea mexicana*. This cross, *Nymphaea helvola*, is not only a deeper yellow than *Nymphaea mexicana* but is somewhat larger and less strictly four-sided than *N. tetragona*. A sport of *Nymphaea tetragona* was described in 1942 as var. JOANNE PRING. This variety has deep pink flowers, lighter at the tips of the petals, and stamens of an orangish hue.

GIANT AND PYGMY WATER-LILIES
(*Nymphaea* MISSOURI and *N. tetragona*)

3. GIANT WATER-PLATTER.—

The date of discovery of the Giant Water-Platter is probably 1801, in which year the botanist Haenke was sent by the Spanish government to investigate the flora of Bolivia. From his canoe on the river Mamoré, one of the tributaries of the Amazon, he is reported to have seen in the marshes along the stream a flower so unusual and beautiful that he fell on his knees in admiration. Ten years later, another botanist, Bonpland, discovered the same plant near the town of Corrientes, Argentina. Schomburgk, in 1836,

Giant Water-Platter *(Victoria Cruziana)*

found it again in British Guiana and sent figures and specimens of it to Kew Gardens in England. From these the plant was described as *Victoria regia* in honor of Queen Victoria. This name appears to have been settled on the northern species, while the plant found in Argentina was named *V. Cruziana* in honor of General Santa Cruz. The two species are nearly identical, but *V. Cruziana* is handled somewhat more easily in St. Louis since it is a native of the comparatively cooler Upper Amazon. This is the lily pictured on the cover of the BULLETIN.

In 1849, after many failures, the flowering of this giant lily under cultivation was accomplished at Kew Gardens. From this stock the plant was distributed to gardens in Europe, Asia, and America. Up to 1853 it was found only in greenhouses, but later it was grown outside in some localities.

Henry Shaw was one of the first to introduce the Victoria in the West, the St. Louis climate being well adapted to this plant. Mr. James Gurney, Superintendent of Tower Grove Park from 1889 to 1920, obtained remarkable results in growing the plant at Tower Grove Park.

The Giant Water-Platter has circular leaves measuring up to six feet in diameter, with upturned edges. Although thin they are strengthened by a framework of veins and are thus capable of sustaining a great weight—up to 150 pounds. The flowers measure 12 to 14 inches in diameter. They are nocturnal bloomers, white the first night of blooming, later turning pink. The older flowers have a fragrance strongly resembling that of pineapple. The flowers, stems, and leaves are all armed with dagger-like spines.

Sometimes the plant has eight to ten leaves growing from its center. To accommodate a water-lily of this size the pool should be at least 20 feet in diameter. In a natural pool it will have sufficient room for root development, but in a constructed pool a cubic yard of soil should be allowed for each plant. The amateur gardener need not be dissuaded by these measurements as the size of the plant may be governed by the amount of soil given the roots, and a small specimen may be grown in an ordinary half barrel.

Since the season for this lily outdoors is only four months, the seed-pods seldom ripen in the pool. After the first light freeze they should be cut off the plant and placed in a tub of water in the greenhouse, leather gloves or forceps being used for the pods are more spiny than cacti. The water should be changed before it becomes black and putrid. When the seeds are free from the pod and show a light yellow color (about six weeks), they should be separated from the pulp by screening. Experiments have shown that the seeds ripen more quickly when packed in a tin box between layers of fine moist sand and kept at a temperature of 60° F. Germination is also hastened when seeds are ripened by this method. The box should be kept securely fastened, since rats and mice are extremely fond of the farinaceous seeds.

It is essential that the seeds be fully ripe before being planted, those two years old showing a better percentage of germination than young seeds. Seeds have been known to germinate in the pool outside (despite it being drained in the winter) three years after the plant had been grown there. Ripe seeds are about the size of an ordinary garden pea and are dark brown to black in color. They should be planted in shallow pans about March 1, about twice their depth, in a medium of half sand and half soil screened through a ¼-inch sieve. The pans should then be submerged in a tank of water filled to three inches above the tops of the pans and heated to 80° F. Within three to four weeks germination is evidenced by a needle-like shoot appearing from the soil. A long lance-shaped submerged leaf and an ovate floating leaf are the next stages. When two oval floating leaves have de-

veloped, the seedlings should be separated and planted in 3-inch pots, using three-fourths sod soil and one-fourth sand. To prevent the soil washing out a piece of broken flower-pot or a layer of moss should be put in the bottom of the pot, and a ¼-inch layer of sand sprinkled on top of the soil after potting. As a fertilizer either inorganic manure, with an analysis of 10 nitrogen, 8 soluble acid phosphate, and 6 soluble potash, or cow manure has proven satisfactory. When the pot becomes filled with roots the plant should be transplanted into an 8-inch pan, which is large enough to carry it through until planted outside.

Victorias should not be planted outside until the temperature of the water is about 75–80° F. This is usually between June 1 and June 15 in St. Louis. Plenty of root room and free use of manure is essential to bring this plant to giant proportions in eight weeks, its period for maturing. When planted in natural ponds, as at the Garden, an area of 100 square feet should be outlined and covered with two inches of cow manure, or one ounce per cubic foot of the inorganic manure, either of which should be spaded under at least one foot in depth and mounded up slightly at the center to indicate place of planting. When first planted outside the leaves are generally about one foot in diameter. As their stems develop they should be pegged to prevent the leaves being torn during wind-storms.

4. EURYALE FEROX.—

Prior to the introduction of the Victorias, *Euryale Ferox* was looked upon as the giant lily. This plant is indigenous to India and China, and is not as handsome a specimen as its Amazonian relative. Its leaves are flat, measuring 4 and 5 feet across, and the purple flowers are small and insignificant. Euryale is perfectly hardy in St. Louis, that is, the plant will resow itself in the ponds during summer. The following spring the seeds will germinate readily, it being necessary to thin out the young plants.

THE MISSOURI BOTANICAL GARDEN

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SOME FACTS ABOUT THE GARDEN

The Missouri Botanical Garden was opened to the public by Mr. Henry Shaw about 1860. From that date until his death in 1889 it was maintained under his personal direction. Although popularly known as "Shaw's Garden" the name Missouri Botanical Garden was chosen by Mr. Shaw and he definitely indicated that he wished it called by that name. The Garden passed at his death into the hands of a Board of Trustees, designated in Mr. Shaw's will, and the Board so constituted, exclusive of certain ex-officio members, is self-perpetuating. By a further provision of the will the immediate direction of the Garden is vested in a Director, appointed by the Board. The Garden receives no support from city or state but is maintained almost exclusively from the estate left by Henry Shaw. Since 1939 many Garden Clubs and interested individuals have contributed to a "Friends of the Garden Fund" which is used in developing the new Arboretum, located at Gray Summit, Mo. The Arboretum (1) serves as a source of plants, trees and shrubs for the city Garden; (2) affords areas for gradually establishing a pinetum, a wild-flower reservation and various other features on a scale not possible in the city; (3) provides greenhouses for some 20,000 orchid plants.

The city Garden comprises 75 acres, where about 12,000 species of plants are grown, both out of doors and under glass. It is open every day in the year except New Year's Day and Christmas; week days, 8:00 a. m. until 7:00 p. m.; Sundays, 10:00 a. m. until 7:00 p. m. The greenhouses are closed every day at 5:00 p. m.

The main entrance to the Garden is at Tower Grove and Flora Place, on the Sarah bus line (No. 42). The Tower Grove bus (No. 21), direct from downtown, passes within three blocks of the main entrance.

MISSOURI BOTANICAL GARDEN BULLETIN

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Missouri Botanical Garden Bulletin

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REDUCING GARDEN UPKEEP

PAUL A. KOHL

Most of us have the experience, when first we take up gardening, of being fired with enthusiasm and attempting so much that soon we slave for our plants instead of enjoying them. Our friends come to admire our garden, but we are weighed down by the cares of spraying, feeding, staking, mulching, watering, transplanting, weeding, mowing, edging, labeling, and—you know the rest—pruning, spading, etc. It's all in your notebook.

Gardening is not possible without effort but it can be simplified by choosing carefully plants which require very little care. In designing the modern garden every effort should be made to reduce the cost of upkeep in time and labor. For example, a grass walk needs constant attention to keep it cut and edged, but a permanent walk and edging remain in good condition for years. Certain groups of plants need to be staked, sprayed, and watered to bring them to perfection; others are beautiful but soon die and must be replaced; still others grow so well as to encroach upon their neighbors, or re-seed themselves and become a positive nuisance. There are many fine trees which periodically shed their bark, leaves, twigs, and seeds. Certain shrubs must be pruned at least once a year to keep them within bounds or prevent them from suckering and forming a tangled mass of twigs; some shrubs might look well when small, but soon outgrow their surroundings. These are some of the many things to consider in planning a garden which will create the effect we desire, but with maintenance reduced to a minimum.

Long-lived perennials, which need not be divided for five or more years, form the backbone of a border planting. Consider what little care herbaceous and tree peonies require and yet each year fill their allotted space in the flower border and remain in good condition throughout the growing season. The trouble-free daylilies do the same, and by using the many new varieties their blooming period may be extended far into the summer. Both of these perennials can remain in the same location for many years; a little

A fine permanent planting of Yuccas in the Linnean Garden

feeding once a year and the removal of the dead foliage is all the attention that they need. Baptisia, Yucca, gas plant (Dictamnus), globe thistle (Echinops), plantain-lily (Hosta), Siberian Iris, Silver King Artemesia, and Tartarian Aster are other fine large, permanent perennials. Of those growing about a foot high we could use *Anchusa myosotidiflora,* various pinks (Dianthus), evergreen candytuft (Iberis), Stokes aster (Stokesia), coral-bells (Heuchera), Teucrium, *Iris tectorum*, and *Sedum spectabile.* If we compare all of the above perennials with some of our short-lived favorites, we can note the difference. Columbine (Aquilegia), lupine (Lupinus), and Delphinium are very beautiful and are a part of every garden, but can we expect them to fill the flower border each year and throughout the summer? Isn't it true that suddenly a fine columbine collapses, or a lupine fails to grow, while Coreopsis, golden Marguerite *(Anthemis tinctoria)*, hollyhock (Althaea), and false dragonhead (Physostegia) spread by seeds or suckers so that they must be weeded out?

If we add bulbous plants such as narcissi and the best of the lilies to the border we have a group of plants which will brighten our garden each year, but will not require much of our time for upkeep.

There is more work in the flower border when annuals are combined with perennials. Annuals are good for filling the gaps left vacant by hyacinths,

Tree Wisteria growing in Linnean Garden

tulips, or Oriental poppies, but the number we grow should depend upon our time and whether we will be present to enjoy them when they bloom.

In selecting hedge plants, soil, available moisture, exposure, length and height, cost and number of shearings per year are some of the things to be considered. Privet (Ligustrum) is cheap, grows rapidly, has good color, is semi-evergreen, but does need five or six clippings a year. Yew (Taxus) is evergreen, grows slowly, needs only one shearing a year, but is expensive. Various types of barberry (Berberis) are better than privet in that they need to be sheared less frequently. Color and texture are different, however, and the Japanese variety has the bad habit of holding many dry leaves during the winter. For hedges of various heights we might consider truehedge columnberry *(Berberis Thunbergii* var. *pluriflora)*, *Euonymus patens*, winged Euonymus *(E. alata)*, Regel's privet *(Ligustrum obtusifolium* var. *Regelianum)*, or *Viburnum lantana.* These do not need as much shearing as California privet, are free from insects, and do not winter-kill.

Broad-leaved evergreen shrubs are worthy additions to any garden. Evergreen barberries, American and Japanese holly (Ilex), boxwood (Buxus), Mahonia, *Pieris japonica*, and yew are good. Kalmia and Rhododendron do well in regions of abundant moisture, but need constant watering to keep

them growing in the St. Louis area. Some desirable shrubs which need very little care are Mentor barberry *(Berberis mentorensis)*, Jetbead (Rhodotypos), star magnolia *(Magnolia stellata)*, *Viburnum Carlesii*, *Rhus aromatica;* and for larger borders, highbush Cranberry *(Viburnum trilobum)*, *Viburnum tomentosum*, Amur maple *(Acer ginnala)*, bottlebrush buckeye *(Aesculus parviflora)*, witchhazel (Hamamelis), Cornelian cherry *(Cornus mas)*, lilacs (Syringa), and beauty-bush *(Kolkwitzia amabilis)*. There are many other good shrubs, but some of them need more care. For instance, twigs of Kerria freeze in some winters and must be pruned; some shrub roses are subject to scale; forsythias need thinning, and *Forsythia suspensa* ought never to be planted except on banks, as every tip roots to form another plant; pearl-bush (Exochorda) dies back; and rose acacia *(Robinia hispida)* spreads by suckers.

Before a tree is planted, its ultimate height should be considered. It is a mistake to plant a cottonwood or sycamore, both of which might be recommended because of their rapid growth, when a smaller tree would be in better scale with the surroundings. Furthermore, in ten years such trees shade a large area so that it is impossible to grow any worth-while plants under them and they rob the soil of food and moisture. Of the good trees which average about twenty feet in height, we can select flowering crabs (Pyrus), hawthorns such as the Washington thorn *(Crataegus phaenopyrum)*, flowering dogwood *(Cornus florida)*, saucer magnolia *(Magnolia Soulangeana)*, sweet bay *(Magnolia virginiana)*, European beech *(Fagus sylvatica)*, varnish tree *(Koelreuteria paniculata)*, Japanese pagoda tree *(Sophora japonica)*, and possibly redbud *(Cercis canadensis)*. Taller trees are the oaks, pin oak *(Quercus palustris)* being a very good tree for city planting; sugar and Norway maple *(Acer saccharum* and *A. platanoides)*, linden *(Tilia americana)*, sweet gum *(Liquidambar Styraciflua)*, bald cypress *(Taxodium distichum)*, and Ginkgo. The American Elm is on the doubtful list at the present time because of the Dutch Elm disease and other diseases. Sycamore and tulip tree *(Liriodendron tulipifera)* have the bad habit of shedding many leaves during the summer.

Ground-cover plants should be freely planted under trees, where grass will not grow, and as a permanent cover in shrubbery beds. They improve the appearance of any planting and when well established retard the growth of weeds. English or Balkan ivy *(Hedera Helix)* and myrtle *(Vinca minor)* are two of the best, and a third choice would be the purple-leaf wintercreeper *(Euonymus Fortunei* var. *coloratus)*.

Evergreens are a part of every garden. As a background they enhance the beauty of other plants and in winter brighten an otherwise cheerless landscape.

DELPHINIUMS

GUSTAV A. L. MEHLQUIST

From the standpoint of origin and landscape effect, the garden delphiniums may be divided into five groups:

1. The AJACIS group is so called because it has been largely derived from *Delphinium ajacis*, although it is quite likely that *D. consolida* and *D. orientale* have also been involved. This group is represented by vigorous-growing annuals (figs. 1 and 2), available in single- and double-flowered forms of every color except yellow.

2. The CHINENSIS group is largely descended from *D. chinensis* (fig. 3). Actually, however, the cultivated *D. chinensis* is a form of the Siberian *D.*

Fig. 1. "Regal Pink"

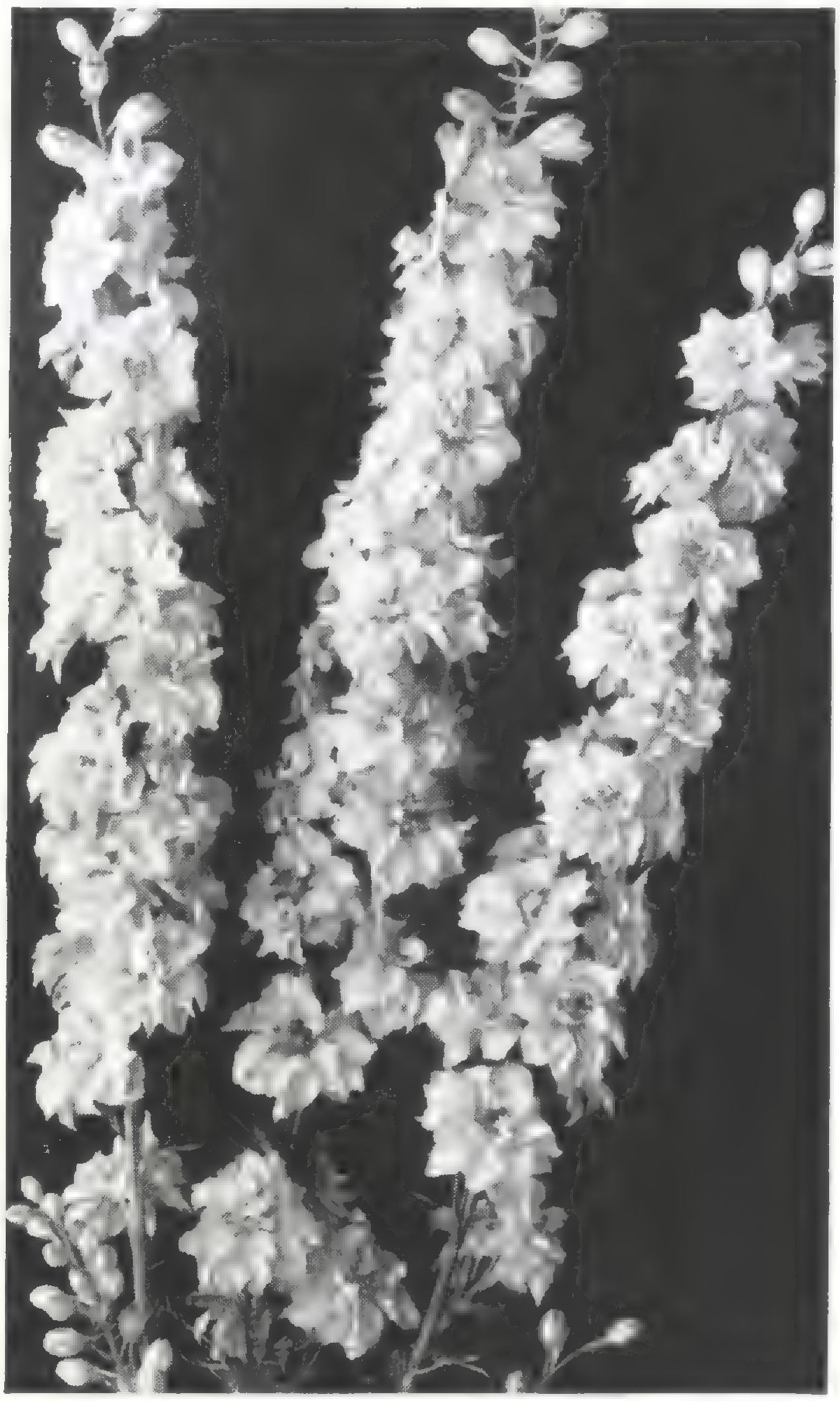

Fig. 2. "Great Imperial Pink King"

Two of the AJACIS group of Delphiniums

Fig. 3. "Blue Butterfly," of the CHINENSIS group of Delphiniums

Fig. 4. Unknown variety

Wrexham delphiniums started in 1927 from seed

Two of the ELATUM group of Delphiniums

grandiflorum. It is possible that the very similar *D. tatsienense* from the same general region has also contributed to its development. The varieties ordinarily sold as *D. chinensis* seldom exceed two feet in height and are so profusely branched that often they are broader than high. Violet-blue, sky-blue, and white are the only colors available in this group. Some years ago double-flowered forms were grown but in recent years only single-flowered types have been available. In seed catalogues they are often classified as annuals because they readily flower the first year from seed if planted early, and frequently they fail to survive more than one year under adverse climatic conditions.

Fig. 6. "Pacific Giants," of the ELATUM group of Delphiniums

'. The ELATUM group, the tall-growing so-called "hybrid" delphiniums (figs. 4–6), is probably for the most part derived from *D. elatum* and related species from the European Alps. This group, which is by far the most common one in gardens today, is made up of a multitude of forms. They vary in color from pure white through all shades of blue and violet to

deep purple. They do not branch much but tend to shoot straight up, often reaching a height of 6–8 feet in cooler climates. It is not only in height that this type excels, but also in the size of individual flowers which often reach a diameter of more than 3 inches. Double and semi-double forms predominate, but singles are still grown. In Europe, particularly in England, this type of Delphinium has been highly prized as a garden plant, selected seedlings usually being propagated by cuttings or division and sold as named varieties. In this country, especially in the Southern states, where losses from various fungi and virus diseases often are high, propagation is largely by seed. A strain, known as "Pacific Giants" developed by Vetterle & Reinelt in Capitola, California, has found much favor in this country in recent years. It is shorter-lived than the older types, but this shortcoming is more than compensated for by the fact that it often blooms in six to ten months from seed, producing magnificent spikes of large, well-formed flowers. The strain is offered in several named forms that come practically true from seed and compared to the older strains, produce a very high percentage of fine things.

4. The BELLADONNA group (fig. 7) is intermediate in appearance between the CHINENSIS and ELATUM groups. This is understandable, as it now appears reasonably certain that the BELLADONNA group arose through hybridization between them. In addition to the typical "Belladonna," which is sky-blue, this section contains two dark blue forms, "Bellamosum" and "Lamartinii," and a white form, "Moerheimii." The last form has never been common in this country, probably because it does not produce seeds and so must be propagated by cuttings or through division. Next to the annual forms, the BELLADONNA varieties are the most useful for cut flowers.

5. The RUYSII group constitutes the newest section of garden delphiniums, having been available only about ten years. Its members are all derived from a chance cross between *D. nudicaule*, a dwarf red-flowered species from northern California, and a member of the ELATUM group. The cross took place in Ruys Nurseries in Dedemsvart, Holland. The forms available in this country have been introduced by the Jackson-Perkins Company, of Newark, New Jersey. They appear to be doing best in the cooler sections, and where they thrive they constitute a delightful addition to the garden delphiniums. They are pink-flowered and in habit rather similar to BELLADONNA. They are normally propagated by means of cuttings or divisions.

Culturally, all garden delphiniums have one thing in common: they will not be able to do their best unless they have an opportunity to build up an adequate root system and complete the rosette stage before the onset of the hot weather. Furthermore, they like to have their roots, which are usually close to the surface of the soil, protected against the hot sun. To meet these requirements, seeds of delphiniums should be planted in this region in late

Fig. 7. "Bellamosum," of the BELLADONNA group of Delphiniums

summer or very early spring. The annual forms resent transplanting, so they should preferably be sown directly where they are to flower. Some years fall-sown plants do best, at other times spring-sown ones, so it is wise to plant some seed at both seasons. The latter part of September through October and then again in February or March are good seeding times for annual delphiniums. It is not necessary or even desirable to wait until the ground can be worked in the spring. If the bed were spaded in the fall, as it should have been, the surface need only to be raked lightly to make a good seed bed. In fact, annual delphiniums and Iceland poppies can be sown on the snow. As the snow melts, the seeds will sink into the soil and germinate as soon as temperatures permit. Annual delphiniums prefer a well-drained, sandy, not too rich soil, but will do well in most soils if given proper care.

The perennial delphiniums transplant well, and since the seed of good forms in this group is often rather expensive it should be sown in a well-prepared seed bed, preferably in a cold-frame or greenhouse. The seed of the ELATUM types, such as "Pacific Giants" and others, does not germinate well in hot weather. As it must be planted in late August or early September in order to produce fair-sized plants by winter a cool shady place should be chosen. A cold-frame facing north or located on the north side of a building will serve the purpose well. Ordinary garden soil over which has been spread a two- or three-inch layer of two-thirds well-rotted leaf mold and one-third sand will make a good seed bed. The seeds may be drilled or broadcast but in either case should be covered with about one-fourth inch of the compost. The frame should be covered with shaded glass or lath shades until the seeds have germinated. A glass-covered flat will do for small quantities of seed if it is placed in a shaded place. As soon as the seedlings have two or three leaves, they should be transplanted to another frame and set three to six inches apart. It is best to winter the plants in this frame or bed, covering them lightly with branches and dry leaves. A heavy layer of leaves will smother the plants unless kept from packing by means of branches laid directly over the plants. The following spring the seedlings should be transferred to the beds where they are to flower. A second batch of seed may be planted in a similar way early in the spring. If the seed is planted in February or March, the plants can probably be transferred to the garden in time to become established before the summer heat sets in. If early planting cannot be done, the plants had better be left in the frame until the following spring.

Vegetatively reproduced named varieties of delphinium are best set out in early spring. Plants that do well should be lifted and divided every two to three years. Usually the divided plants make their best showing the second year, so it is wise not to divide all plants in any one year. Although mem-

bers of the CHINENSIS and BELLADONNA groups divide readily, division is seldom practiced for these groups as they reproduce very readily from seed. Furthermore, the seed is very inexpensive and remains viable for one to two years unless exposed to high temperatures. On the other hand, seed of the ELATUM group is often rather expensive and does not keep well, so strictly fresh seed should be used for best results.

Perennial delphiniums, particularly those of the ELATUM group, require a rather rich, well-drained soil for best development. If possible, a fair amount of well-rotted manure or leaf mold should be incorporated in the soil shortly before planting time. As soon after planting as possible, and certainly before the summer heat sets in, the soil between the plants should be mulched with leaf mold. Half-rotted leaves will do. I know of no herbaceous plant that is so greatly benefited by a leaf-mold mulch, 1 or 2 inches thick, as delphinium. The mulch will do four things: (1) protect the fine surface roots from the sun; (2) conserve moisture; (3) provide good conditions for bacteria, which will further decompose the leaf mold and thereby release a steady stream of nutrients directly available to the roots; (4) decrease the number of weeds, as seeds in the soil underneath do not germinate readily through the layer of leaf mold. Cultivation of the soil should be kept to a minimum, for, contrary to many garden books and magazines, frequent cultivation does not conserve moisture; it reduces it and generally does more harm than good to surface roots.

Delphiniums, as other plants, are subject to attacks by disease and insects. Leaf spots and mildews are common, but can be largely prevented by weekly dustings of flower of sulphur or sprayings of wettable sulphur up to the flowering time. Sulphur must not come in contact with the flowers as it causes injury. Red spider mite and leaf hoppers are the chief insect pests of delphiniums, but fortunately these insects tend to shun plants that are well covered with sulphur so this substance is of double value. However, should red spiders and leaf hoppers become troublesome, any standard brand of insecticide combining pyrethrum and rotenone will control them. "Black Leaf Forty" and other nicotine sprays are not effective against these insects. One or two applications of a 4-12-4 or 5-10-5 fertilizer at the rate of three to five pounds per 100 square feet of soil space will greatly benefit delphiniums once they are well established.

Many people are in the habit of referring to the annual forms of delphinium as "larkspur" and to the perennial forms as "delphinium." There is no basis for this distinction. Delphinium is the botanical name of the genus to which all the species belong, and "larkspur" is the accepted common name in all English-speaking countries for all the species of this genus, whether annual or perennial.

THE FORMOSA LILY

GUSTAV A. L. MEHLQUIST

The Formosa lily *(Lilium formosanum)* is native to Formosa as the name implies. In the trade it is often erroneously offered under the name of *L. philippinense* var. *formosanum* or even as *L. philippinense*. However, *L. formosanum* and *L. philippenense* are quite distinct.

Lilium philippinense Baker is a slender-stemmed plant bearing long tubular flowers pure white inside, greenish white outside, sweetly scented. Under favorable conditions it may reach 4 feet but is usually only 2–3 feet tall. One of the most distinct features of the flower is the bluish stigma, a characteristic apparently not known in any other lily. Unfortunately *L. philippinense* is not reliably hardy in this region although it may be so in the South. It is a delightful greenhouse plant.

Lilium formosanum Stapf is a vigorously growing plant sometimes reaching 8 feet in height. This lily was discovered in 1858 but apparently was not flowered in Europe until about 1880, by Veitch Nurseries in England. It passed out of cultivation but was re-introduced in 1918 by E. H. Wilson. Because of the ease and rapidity with which this species can be flowered from seed it is now fairly common in American gardens. It is quite variable in height and many other characteristics and is so amenable to selection that different strains developed for the trade often have little in common. No matter what the form or strain, it is a beautiful lily well worth a place in any garden. The so-called Wilson's form, which is the common one in American gardens, varies in height from 2 to 8 feet and bears from 3–20 large tubular flowers white on the inside and greenish pink on the outside. The color of the pollen varies from a golden yellow to deep brown. Strains are now advertised that are said to be pure white but in all I have seen the flowers had some flush of color on the outside unless greenhouse grown.

An exception as regards variability is the alpine form, *L. formosanum* Price's variety, which comes quite uniform from seed, seldom exceeding 18 inches in height, and flowering from four to six weeks earlier than the typical form. It has fewer and more slender trumpets and is said to be hardier.

Regardless of form or strain, fresh seed of the Formosa lily germinates in ten to fourteen days. If the seed is a year or more old a little longer may be required, but usually it comes up within a month. The seed for the plants shown in the photograph was sown in February, 1946. The seedlings were transferred to 2 x 2-inch plant bands* as soon as they were large enough to be handled with ease and set out about May 15. The first flowers appeared in August of 1946, and there is little doubt but that they would have made

*Small collapsible bottomless frames to separate plantlets within the flat.

quite a good showing until frost had it not been for a bad storm on September 2, which levelled them to the ground.

The lilies were given a 4-inch mulch of half-rotted leaves in October to prevent the young bulbs being lifted by the frost. At this time none of the bulbs exceeded 1 inch in diameter. Most of them survived the winter and did quite well in the summer of 1947. Three different selections based on height had been planted. The "short" form did not exceed 30 inches and bore from two to five flowers per stem. The "tall" selection reached 6 feet and bore up to fifteen flowers per stem. The "medium" selection was intermediate in height and flower number. The "short" began to flower late in July and was practically through before the "tall" began in early September; and the "medium," being intermediate, overlapped both the other selections

Formosa lily grown at the Garden; photographed July 29, 1948.

in flowering season. The performance was repeated the summer of 1948 except that the number of flowers per stem was greater, the most being twenty-two. The number of stems per plant was also greater, especially in the "short" selection where many plants had as many as five stems. Probably about one-half of the original seedlings have died during these three years but the increase in size per plant has more than compensated for this loss.

The reasons that the Formosa lily is not even more commonly grown are probably three. First, many people do not realize how easily and quickly this lily can be grown from seed. Second, they seem worried about its reported susceptibility to mosaic. It is true this lily is very susceptible to mosaic but since the disease is not ordinarily transmitted through the seed every new batch of seedlings is free from the disease until caught from diseased lilies that are already in the garden. Many lily clones (vegetatively reproduced varieties) now in the trade are infected by mosaic. This disease is readily spread from infected plants to healthy ones by means of aphids that frequently feed on lilies. *L. formosanum* being more susceptible to mosaic than most other lilies will show the disease quickly and usually will be ruined. Infection can be prevented by effective control of the aphids, possible by spraying or dusting the plant with nicotine-sulphate or pyrethrum-rotenone. Third, basal rot is a factor in killing this lily. However, this disease is not so serious if the plants are grown from seed and are left undisturbed once they are in the garden. In fact, the best stands of the Formosa lily that I have seen have been from seedlings that were not moved after they were put into their "permanent" place. A well-drained location is usually recommended and is undoubtedly to be preferred, but some very fine stands have been grown in heavy soil that was anything but well drained.

The Missouri Botanical Garden has a limited amount of seed that was harvested last fall. Subscribers to the BULLETIN and "Friends of the Garden" may obtain some of this seed by sending in a request accompanied by a stamped self-addressed envelope. Plant the seed as soon after receiving it as possible. Transplant the seedlings into plant bands or small pots and transfer the young plants to the garden as soon as they are large enough. Mulch during the winter with half-rotted leaves or compost to prevent the frost from lifting the small bulbs and you will probably have lilies in your garden.

Ste. Genevieve County is much more "southern" than is St. Louis. Not only can many southern species that are doubtfully hardy in the St. Louis area be overwintered there, but bluets and annual blue grass usher in the flowering season of the pasture a week in advance of St. Louis.

A PROLONGED SPRING FOR 1949?

ROBERT W. SCHERY

There is no better way to judge when spring is actually with us than by the first timid flowering of crocus, snowdrop and early trees, braving the rigors of February and March. These fifth-columnists to the winter rise through that season's late dreariness to lift one's spirit in anticipation of green months ahead, when nature's productive work, the building from air and soil the bounty of the land, will become reality.

An annual custom of recent years has been to announce in the BULLETIN what the Garden plants "think" about the springtime. Just a year ago, on the basis of early returns, we predicted an "average" spring—neither unusually early nor unusually late. Flowering dates through April, as are listed in the accompanying chart, proved this to be correct. And each year gives further evidence of how phenomenally early was the spring of 1946, when lilacs, wild cherry, and blue grass had already flowered by the date this BULLETIN will have reached you. Likewise, looking back into the flowering record, we see evidence that spring of 1947 was late—almost two weeks later than 1948's "average" year. Let's see how spring 1949 shapes up on the basis of returns as this goes to press.

Looking to the chart we see that spring, as announced by the plants, started early this year—not quite so early as 1946, but as much as two weeks ahead of last year and nearly a month ahead of 1947. This perhaps was a reflection of a rather mild winter and unusually warm days in mid-February and very early March. The plants gave evidence that spring had started that early, although doubtless as you sniffled through sub-freezing weather in mid-March such an ephemeral boast might well have been ill-remembered.

It was this very return of winter's wrath, giving us four snows, one of them the winter's heaviest, and temperatures as low as 13° F. between March 10 and March 19, that "prolonged" the spring. The delay set back 1949 behind 1948's "average" schedule, a loss of about two weeks in time (or a gain of this much in the length of springtime). The cold snap did not seem to harm the buds or early flowers. Crocuses came through the melting snow in full flower, and Cornelian cherry *(Cornus mas)* remained with open blossoms while 20° F. winds blustered through St. Louis on March 15. Goldenbell (Forsythia), flowering only haphazardly with a few flowers on the date given in the chart, and fragrant honeysuckle closed its flowers to await the warmer weather of late March. Thus the early-started spring 1949 is now drawing out into a rather protracted schedule. It may interest readers to compare flowering dates yet to come in April with the chart showing these for years past.

SOME SPRING FLOWERING DATES, 1946–1949

Plant	First flowering				Days earlier (+) or later (—) than 1948:
	1949	1948	1947	1946	
Crocus, early yellow *(Crocus)*	Feb. 13	March 2			+17
Snowdrop *(Galanthus nivalis)*	Feb. 13	March 2		Feb. 27	+17
Silver maple *(Acer saccharinum)*	Feb. 21	Feb. 28	March 24	Feb. 11	+ 7
Cornelian cherry *(Cornus mas)*	March 5	March 17	March 18	Feb. 28	+12
Elms, Chinese and others *(Ulmus parvi-flora,* etc.)	March 5	March 17	March 24	Feb. 18	+12
Hazel, European *(Corylus avellana)*	March 5	Feb. 29	March 24		— 5
Fragrant honeysuckle *(Lonicera fragrantissima)*	March 7	March 18	March 24	Feb. 28	+11
Goldenbell *(Forsythia suspensa Fortunei)*	March 7	March 21	April 2	March 4	+14
Daffodils *(Narcissus* spp.*)*	March 21	March 21	April 2		0
Japanese Andromeda *(Pieris japonica)*	March 22	March 22	April 1	March 18	0
Chickweed *(Stellaria media)*	March 23	March 24	April 1	March 5	+ 1
Fragrant sumac *(Rhus aromatica)*	March 28	March 22	April 7	March 21	— 6
Shepherd's purse *(Capsella bursa-pastoris)*	March 29	March 22			— 7
Magnolia, saucer *(Magnolia Soulangeana)*	March 29	March 24	April 7	March 5	— 5
Cottonwood *(Populus deltoides)*	March 30	March 26	April 7	March 21	— 4
Boxelder *(Acer Negundo)*	March 31	March 26	April 7	March 8	— 5
Ornamental cherry or plum *(Prunus* spp.*)*	March 31	April 1	April 7	March 4	+ 1
Sassafras *(Sassafras albidum)*	April 5	April 6	April 21	March 18	+ 1
Ash *(Fraxinus* sp.*)*	April 6	April 3	April 7	March 18	— 3
Gooseberry *(Ribes aureum)*	April 7	April 7	April 21		0
Redbud *(Cercis canadensis)*	April 8	April 6	April 25	March 6	— 2
Spiraea and other shrubs		April 5	April 20	late March	
Lilac *(Syringa vulgaris)*		April 7	April 27	March 26	
Oaks, various *(Quercus* sp.*)*		April 10	April 27	April 1	
Barberry *(Berberis Thunbergii)*		April 14			
Buckeye *(Aesculus* sp.*)*		April 15	April 27	March 27	
Hawthorn *(Crataegus* sp.*)*		April 15	May 1		
Willow *(Salix nigra)*		April 18	April 29	April 5	
Silverbell *(Halesia carolina)*		April 18	May 3	March 30	
Sweetgum *(Liquidambar Styraciflua)*		April 19	May 2	March 30	
Fleabane *(Erigeron* sp.*)*		April 20	May 4	April 20	
Blue grass *(Poa pratensis)*		April 20	April 28	April 5	
Dock *(Rumex crispum)*		April 25	May 7	April 19	
Locust, Kelsey *(Robinia Kelseyi)*		April 27	May 13	April 15	

At the close of the first week of April, wildflower flowering dates are slightly behind those for 1948. Liverleaf (Hepatica), bloodroot (Sanguinaria), toothwort (Dentaria), rue anemone (Anemonella), bluebell (Mertensia), pussy toes (Antennaria) and shadbush (Amelanchier) were all barely in flower April 4, in the Current river valley about 150 miles southwest of St. Louis. These same plants were somewhat farther along on April 1, in 1948. Various violets, including the Johnny-jump-up (Viola spp.), were well in flower April 4 in the same area, as were spicebush (Lindera), alder (Alnus), eastern vervain (Verbena), bluets (Houstonia), and cultivated fruit trees (Prunus). Redbud showed the buds just coloring. Before mid-April these plants should have flowered in the St. Louis area.

NOTES

Mr. George H. Pring, Superintendent of the Garden, attended the trustees' meeting of the American Orchid Society, held in New York, March 22–23.

Mr. A. P. Beilmann, Manager of the Garden Arboretum, attended the Midwest Chapter meeting of the National Shade Tree Conference at Chicago, February 18-19, where he gave a paper on diagnosing tree troubles.

The students in botany at Eastern Illinois State College, Charleston, accompanied by Dr. Ernest L. Storer, recently visited the Garden including the library and herbarium.

Volume XXXVI, Number 1, of the ANNALS OF THE MISSOURI BOTANICAL GARDEN, which was issued during the month, represents Part III, Fasc. 4 of Woodson's and Schery's "Flora of Panama," being the third installment of the Orchidaceae, by Paul H. Allen.

Among the recent visitors to the Garden were the following: Dr. Rogers McVaugh, of the University of Michigan; Dr. Lyman B. Smith, of the Smithsonian Institution; Mr. and Mrs. Mundkur, of Bombay, India, now graduate students at Southern Illinois University, Carbondale; Dr. Julian A. Steyermark, of Chicago (Field) Museum of Natural History; Miss Barbara Hoskins, Librarian Antioch College, Yellow Springs, Ohio; Dr. Hamilton H. Card, of Fillmore, Illinois.

Spring is the most difficult time of the year to identify most woody plants. Neither are the winter bud characteristics usable, since buds are swelling and bursting, nor are leaves and flowers sufficiently developed to permit full use of their characteristics usually described in the manuals.

Chickweed in the lawn is already setting seed and completing its growth for the year. Because chickweed flowers so early, most home-owners have not yet gotten around to caring for the lawn before even the grass needs cutting. Yet that is the time of the year when chickweed is most vulnerable. If it can be attacked or eliminated in very early spring there will be fewer seeds to produce next year's plants.

Perhaps the first wild shrub to flower in the state in spring is the interesting spice bush *(Lindera Benzoin)*, frequent along the rivers and in valleys of central and southern Missouri. Clusters of small yellow flowers growing

directly on the stem, appear before the leaves. Within the flower are nine stamens opening by paired "trap-doors," an unusual feature among plants, and three rudimentary stamens. Spice bush is a relative of the Sassafras, also a spring flowerer, and, like the latter, gives out decided fragrance when the twigs are bruised or the young bark scraped. Spice bush is often used as an ornamental shrub, and in age attains the stature of a small tree 10 or 12 feet tall.

A plant oddity to be found in Missouri is the scouring rush or horsetail (Equisetum). These grayish-green, awkwardly rigid plants may be observed at all seasons in poor soils along river banks and railroad right-of-ways. The stem, being leafless, is green and must carry on the vital activities usually associated with leaves. It is also hollow in the center, and even the outer shell is traversed lengthwise by minute canals. The outer tissues are impregnated with silica, so that a handful of scouring rush is quite effective for cleaning the blackened cooking utensils of the camper. Rubbing the ridged stem of a scouring rush over the finger nail will abrade minute canals in the nail, attesting the efficaciousness of its scouring powers. Scouring rushes are related to the ferns, and their now extinct larger cousins were among the chief coal-producing plants. Present-day scouring rushes are, however, a mere remnant and the sole survivors of a once great group. According to popular report a few years back, scouring rushes were said to serve as indicators of gold in Canadian mining fields. Apparently the plants absorb traces of gold when it is present in the soil, and analysis of the plant can reveal the approximate concentration of this metal. It was even hoped that it would be commercially feasible to grow and harvest scouring rushes as a means of "mining" gold thinly dispersed through the soil, but apparently nothing ever came of the idea.

Nests of the Great Blue Heron, a frequent denizen of the more isolated river valleys not far from St. Louis, appear from a distance as huge clumps of mistletoe growing in the uppermost branches of tall trees. The nests are loosely woven from a multitude of twigs, and are literally a "pile-of-brush" in the tops of nest trees. Recently on a canoe trip down the upper Meramec an unusually large colony of these herons and their nests was observed. Forty-nine nests, most of them apparently occupied, were counted in five large, nearly adjacent sycamores. The birds were seen frequenting the nests, and as many as twenty birds were noted in the air about the nesting site at one time. In spite of this heron concentration a truly intrepid frog was heard sounding his call in a slough adjacent to the nest trees.

SOME FACTS ABOUT THE GARDEN

The Missouri Botanical Garden was opened to the public by Mr. Henry Shaw about 1860. From that date until his death in 1889 it was maintained under his personal direction. Although popularly known as "Shaw's Garden" the name Missouri Botanical Garden was chosen by Mr. Shaw and he definitely indicated that he wished it called by that name. The Garden passed at his death into the hands of a Board of Trustees, designated in Mr. Shaw's will, and the Board so constituted, exclusive of certain ex-officio members, is self-perpetuating. By a further provision of the will the immediate direction of the Garden is vested in a Director, appointed by the Board. The Garden receives no support from city or state but is maintained almost exclusively from the estate left by Henry Shaw. Since 1939 many Garden Clubs and interested individuals have contributed to a "Friends of the Garden Fund" which is used in developing the new Arboretum, located at Gray Summit, Mo. The Arboretum (1) serves as a source of plants, trees and shrubs for the city Garden; (2) affords areas for gradually establishing a pinetum, a wild-flower reservation and various other features on a scale not possible in the city; (3) provides greenhouses for some 20,000 orchid plants.

The city Garden comprises 75 acres, where about 12,000 species of plants are grown, both out of doors and under glass. It is open every day in the year except New Year's Day and Christmas; week days, 8:00 a. m. until 7:00 p. m.; Sundays, 10:00 a. m. until 7:00 p. m. The greenhouses are closed every day at 5:00 p. m.

The main entrance to the Garden is at Tower Grove and Flora Place, on the Sarah bus line (No. 42). The Tower Grove bus (No. 21), direct from downtown, passes within three blocks of the main entrance.

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Photography by Paul A. Kohl.

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Missouri Botanical Garden Bulletin

Vol. XXXVII MAY, 1949 No. 5

A NEGLECTED ORNAMENTAL TREE FOR THE ST. LOUIS AREA

ROBERT B. NEVINS

It is curious to note the way that people rush to obtain exotic plants for their gardens, at the same time ignoring native plants that are admirably fitted for use in this climate. One such native plant is the bald cypress *(Taxodium distichum)*, one of the three coniferous trees growing wild in the state. It has been recommended by landscape gardeners as an accent plant and as a background tree, and that it thrives in the St. Louis region is well illustrated by the magnificent specimens to be found in the Garden and Tower Grove Park.* Some of these trees were planted nearly a century ago by Mr. Shaw and have well withstood the vicissitudes of our climate.

The bald cypress is a large tree, attaining a height of 130 feet, with some specimens reaching over 150 feet and a diameter of 17 feet. It is long-lived like its relatives the redwoods, and a specimen reaching the aforementioned proportions might well be over 500 years old. One tree in Florida is thought to be 3000 years of age. Another interesting relative of the Taxodium is the recently discovered Metasequoia, a "living fossil" from China.

In its youth Taxodium is narrowly pyramidal, but with age the crown expands and becomes flattened. The tree differs from most conifers in that it is deciduous, although the leaves are retained somewhat longer than those of the hardwoods with which it is naturally associated. The foliage is light green at first, turning darker towards the end of the season, and the many flat "needles" borne at the ends of the twigs impart to the tree a most unusual fern-like texture.

Perhaps the fact that it is traditionally associated with southern swamps accounts for its sparse use as a lawn tree. Usually the mention of "cypress", rather than bringing to mind a suburban lawn, conjures up a vision of tall, fluted trunks rising from still, dark water, with Spanish moss hanging from

* See Mo. Bot. Gard. Bull., Vol. 20, pp. 145–149. 1932; Vol. 28, pp. 111–114. 1940; Vol. 29, p. 234. 1941.

the branches. This is, indeed, the natural habitat of the tree, and in such a setting it is found in southeastern Missouri. Apparently, however, growth is better on a moderately well-drained sandy loam. Normally the growth of hardwoods on such a site is too dense for the bald cypress to get a start, but under good conditions a 10-year-old cypress may have attained a height of 18 feet, and 100-year-old trees are generally about 100 feet high. In the early days cypress was important for lumber, but the quantity now available is so meagre as to preclude extensive logging operations.

Bald cypress is a remarkably hardy tree, and has no important diseases or insect enemies. Before the anti-smoke ordinances were put into effect it was noteworthy as one of the few conifers able to flourish despite the frequent smoke palls. It is an exceptionally wind-firm tree, the branches being rarely blown off by high winds. Furthermore, in the severe ice storms so frequent in this region little damage occurs to this species. In the past winter, for example, when so much breakage occurred to the elms, willows, and soft maples, the Taxodiums in the Garden remained unscathed.

Despite its many virtues, this tree is nevertheless found only in a handful of gardens in the city and county. Let us hope that the future will see an increasing use by home-owners of this interesting and beautiful native tree.

BEAVER TASTE IN TREES

ROBERT B. NEVINS AND LOUIS G. BRENNER

In a bulletin devoted primarily to trees, it might be of interest to see what Missouri's native woodcutters, the beavers, think of the various kinds of trees at the Arboretum and upstream along the Meramec River.

Until the last one or two decades a naturalist on the Meramec would have been hard-put to find cut and gnawed trees indicative of beaver colonies. Twenty to thirty years ago beavers had nearly vanished from Missouri and were totally lacking in the Ozarks. However, they have now been brought back to a stage where their cuttings are no longer a rarity on many of the rivers of the state, and the botanist and zoologist can take pleasure in the handiwork of these furry lumbermen.

Among the earliest colonies of beaver to reestablish themselves in Missouri was the one which was discovered on the Meramec River at the Arboretum in 1939. Here with extensive acreages of cottonwood *(Populus deltoides)* and willow *(Salix* sp.*)*, the preferred food of the beaver in Missouri, the animals found abundant pasture and protection. The Arboretum colony increased rapidly and its range has spread further up the Meramec basin. Today several families of beaver still live along the banks of the river at the

The beaver lodge at the Arboretum

Beaver colony and food pile along bank of Meramec

Beaver slide on Upper Meramec

Tree cut by beaver

Arboretum, and on a recent canoe trip on the upper Meramec, between Meramec Springs and Steeleville three colonies were observed in a half day's easy paddling, with probably as many going unseen.

The beavers living directly on the channel are of necessity "bank beavers," inhabiting burrows along the sides of the river. Any attempt to build the well-known dams and lodges on such a large and fluctuating stream would obviously be futile. In the sloughs bordering the river the traditional dams and mud houses are found. An excellent dam and house were found on an old slough at the Arboretum. At this site it was interesting to note that only trees up to six inches were gnawed despite the fact that all sizes are represented. Willow is used almost entirely in the construction of the dam. Apparently an old log jam has been converted into the house by the addition of a second story of cottonwood and willow saplings.

A bank-beaver colony manifests itself in several ways, the most interesting of which is by cuttings. Cuttings left by beavers in their nightly forays consist of stumps and chewed logs. Sometimes a gnawed tree is found that apparently was too much for the beaver, or did not appeal to his taste. The trees cut, at least in the colonies observed, were generally not more than six inches in diameter, but according to Cahalane* trees up to

* Cahalane, V. H. Mammals of North America. p. 454.

110 feet high and 5 feet 7 inches thick are known to have been felled. If the cuttings are on a bank a slide may be found. These slides are used for easy access to and from the water and for dragging the branches and logs to the river. Nearby, a food stockpile of submerged branches may be seen, looking very much like fresh deposits of debris frequently left by high water. The log, after being stripped of its bark, is often used by lodge beavers in the construction or repair of the house or dam.

Beaver cuttings along the Meramec
Gnaw, gnaw, a thousand times gnaw.

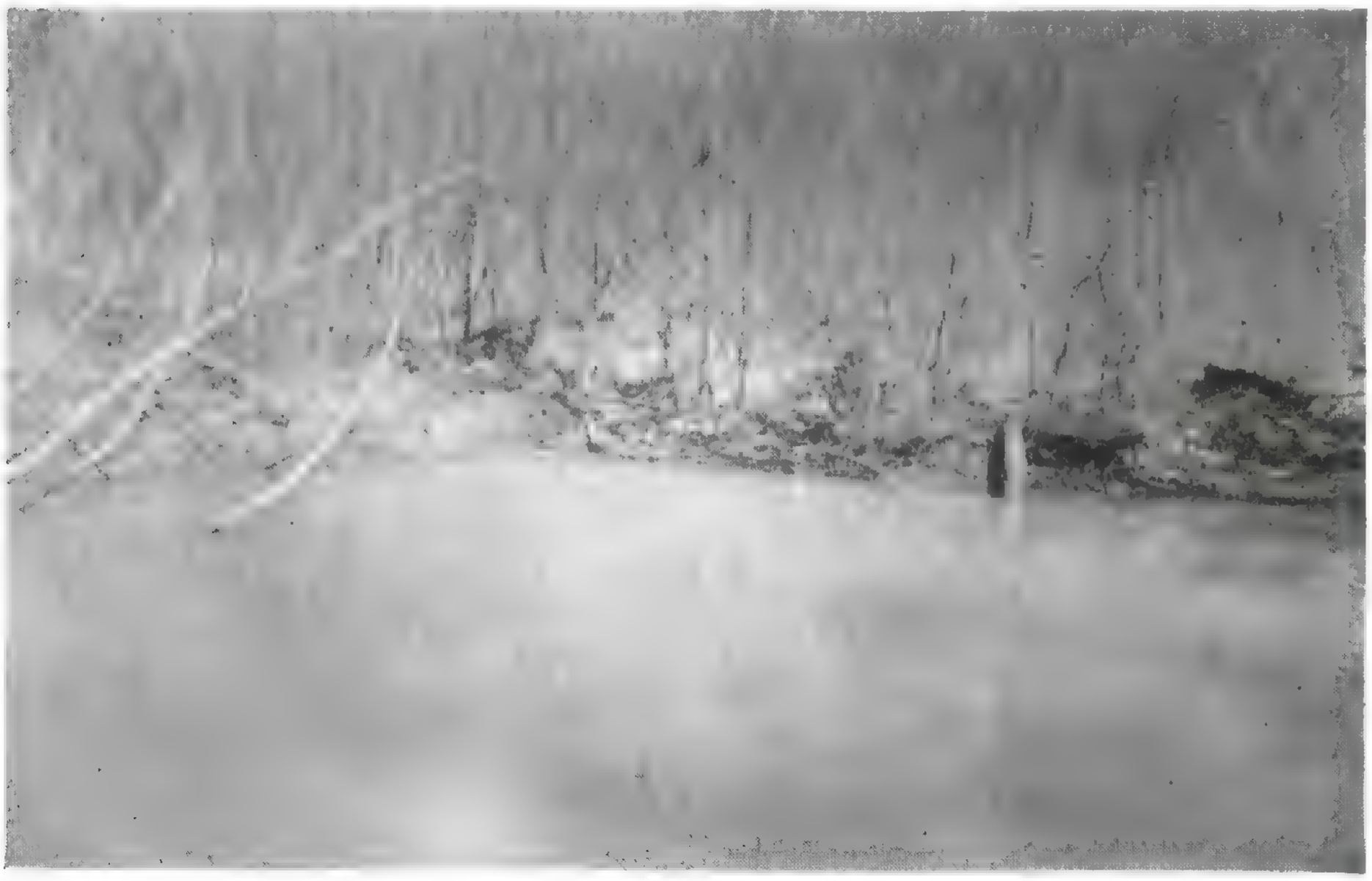
Beavers are commonly thought to subsist mainly on aspen *(Populus tremuloides)*. Although this may be the predominant food in many regions, the Ozark beavers must resort to other foods for the simple reason that there are no native aspens in the southern part of the state. What, then, is consumed? On the lower reaches of the Meramec, cottonwood *(Populus deltoides)* and willows *(Salix* sp.*)* are frequently used. The cottonwood, incidentally, is of the same genus as the aspen, and the willow is in the same plant family. On the upper Meramec, however, cottonwood appears to be rather infrequent, and is scarcely to be seen along the banks upriver from Steeleville.

Upriver from the Arboretum, between Steeleville and Bourbon, soft maple *(Acer saccharinum)* appeared to be the most utilized source of food. Eleven of these trees, three of the related boxelder *(A. Negundo)*, four willows *(Salix* sp.*)*, and three elms *(Ulmus* sp.*)* had been felled. Still higher

up the river, between Meramec Springs and Steeleville, elm was the outstanding favorite, fifteen of these trees (both American and slippery elm, *U. americana* and *U. fulva*) having been cut. At this colony only three maples had been used. A fourth colony, near Steeleville, used ash *(Fraxinus* sp.) and elm in nearly equal quantities but ignored the nearby maple.

A method which might be employed to study further the food preferences of the beaver is feces analysis. The waste of these animals appears to consist largely of undigested wood fragments apparently eaten along with the digestible bark (feces examined showed an estimated 70 per cent volume of wood fragments). Might not analysis of the types of wood cells found give indication of the species eaten and the comparative quantities of each?

In the June 1947 issue of the *Missouri Conservationist* a list is given of the plants known to be eaten by beavers in Missouri, which included fifteen kinds of trees, as well as several aquatic herbs. Cottonwood, however, seems to be the decided favorite when available, along with its relative, the ubiquitous willow. Maple and elm are also apparently well liked, and in some areas are the most frequently cut species. It is interesting to note that two of the commonest river-bottom trees, river birch *(Betula nigra)* and sycamore *(Platanus occidentalis)*, were not used at all in the colonies observed. Beavers seem willing, then, to eat almost any kind of tree, and the figures given above would doubtless vary in other portions of the state and with local variations in the availability of the species.



Dam and pond of the present Arboretum beaver colony

TREE FEEDING

AUGUST P. BEILMANN

In the twenty years that have elapsed since the first article on tree "feeding" or fertilization appeared in the Garden BULLETIN some of the information and suggestions given have had national acceptance. This is gratifying, of course, but it has resulted in complete exhaustion of the three bulletins reporting the work.* Since interest in tree feeding appears just as keen and even more necessary today than it was some years ago, it seems not out of place to revise the articles and to review any facts which might have come to light since.

We must feed a tree to prevent the slow starvation which results if a tree uses all of the available food within range of its roots. In the forest a layer of decomposing leaves adds plant food to the soil through a devious biological chain. On a lawn or along the curb a tree must exist on what food becomes available each year through the slow decomposition of the mineral soil. As such a tree grows its requirements increase and at the same time the root area is restricted by streets and walks. The soil being unable to supply the tree with more than the minimum requirements, the growth rate is much reduced; insects and diseases do more than the usual amount of harm; and eventually the tree dies—a victim of starvation.

The terms "tree feeding" and "tree fertilization" need some clarification. In the field of tree care they mean the same thing: replenishment of soil elements. All plants manufacture food from nitrogen, phosphorus, potash, lime, iron, and many other elements which occur in minor quantities in the soil, including boron, zinc, and manganese. These are carried to the leaves, through the roots and trunk, where, in the presence of sunlight and carbon dioxide, they are synthesized into living tissue. Feeding a tree, then, consists of adding those deficient elements in ways acceptable to the roots. This is commonly done by using commercial grades of nitrogen, phosphorus, potash, calcium, iron, and some of the lesser elements, to overcome the shortages indicated by either soil tests or field work or both.

Most of the experimental work on tree feeding has centered around the large trees, many of which had reached maturity in the sixty or more years since they were set out. Some trees 150 years old were included, since they had successfully bridged the gap between the old prairie and encroaching civilization. To verify the effectiveness of the feeding formulas many smaller trees were used, but none of the work was done in nursery rows or

* (1) The feeding of shade and ornamental trees. Mo. Bot. Gard. Bull. Vol. 17, pp. 119–130. 1929; (2) How to feed a shade tree. Vol. 22, pp. 113–126. 1934; (3) Feeding the shade trees. Vol. 24, pp. 95–113. 1936.

PRESSURE FEEDING GUN

1. Pressure feeding gun in position to drill hole. 2. Half way. Depth of feeding can be controlled. 3. Hole drilled. Ready to charge cylinder with fertilizer. 4. Second charge of 1½ pounds being poured into gun.

pot cultures in the greenhouses. All efforts were directed toward stimulating trees in such a way that there could be no doubt about the effectiveness of the feeding program. For this reason very few check trees were used. It was also found more satisfactory to compare the growth during the five years preceding feeding with that after feeding than it was to locate identical trees which would serve as checks.

The soil within the Garden is of aeolian (wind-blown) origin, called loess, and classed as Muscatine Silt Loam. It has great depth, good water-holding capacity, and uniform texture to a depth of 30 inches where a "hard pan" is encountered. Although this soil is usually considered to be lacking in available phosphorus, additional phosphorus had no effect on tree growth. Only increased amounts of nitrogen stimulated the trees, and above a certain point that did not result in increased growth unless both phosphorus and potash were included in the fertilizer. Eventually the formula was established at 41 per cent nitrogen, and this was the only one in ten years of testing which gave predictable results. In time it became standardized as a 10-8-6 commercial fertilizer, containing 10 per cent of available nitrogen, 8 per cent phosphorus, and 6 per cent potash. Considerable work was done with the "minor" elements—zinc, boron, manganese, magnesium, etc., —but no measurable evidence indicated that they were needed in tree feeding, although their need in fertilizing field and truck crops is very well established.

There is some objection to the use of a "complete" food (one containing nitrogen, phosphorus, and potash) in every case. It is not unlikely that a soil containing adequate amounts of one of the important elements will be encountered. However, until satisfactory testing equipment is readily available it will be better to continue the "shotgun" method of using the complete food, in the hope of supplying the deficiencies. There is also less danger in using this type of tree food since the combination of the three elements will be less likely to "burn" than will a single salt. In addition, the use of just one or two elements may and often does accentuate the need for the missing portion of the formula.

The chemical fertilizers used in this work have all been kinds which were considered as immediately available to plants. No evidence appeared to indicate that fertilizers requiring a year or longer to become soluble were of special benefit. Objections have been raised to the use of these quick-acting materials; they have been likened to a "shot in the arm" which would leave a tree worse off after they leached away. That this is not the case is shown by a group of seven pin oaks *(Quercus palustris)* which after fourteen years were still growing eleven inches taller each year. Before feeding they had grown two inches taller and added one-tenth inch to their trunk diameter annually.

It has been stated that we should never "over-feed" a tree. This is a presumptious remark. Since we all arrived on the scene some 200 years after the destruction of the virgin forest, we can only guess at what should be a "normal" growth rate. If a shade tree grows 6–8 inches in height annually it is in no immediate danger of starving; but it would not be hard to find specimens of the same tree growing four times as fast under certain conditions. If the growth of the branch tips indicates an increase of less than 6 inches a year, the tree is considered in need of additional food. This does not apply to dwarf trees or some horticultural varieties known to grow very slowly. It does include nearly all of the trees ordinarily used on streets or lawns as shade trees.

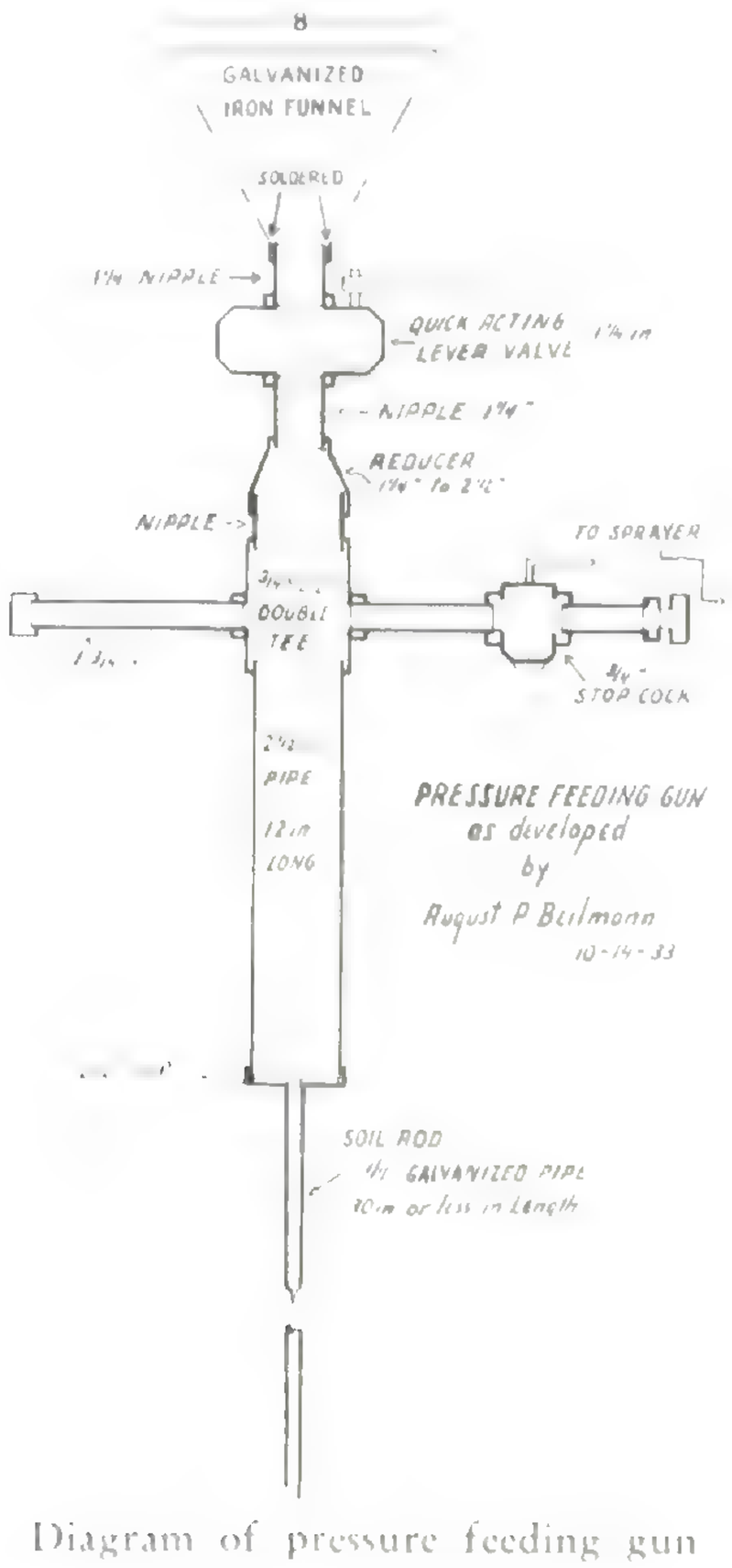
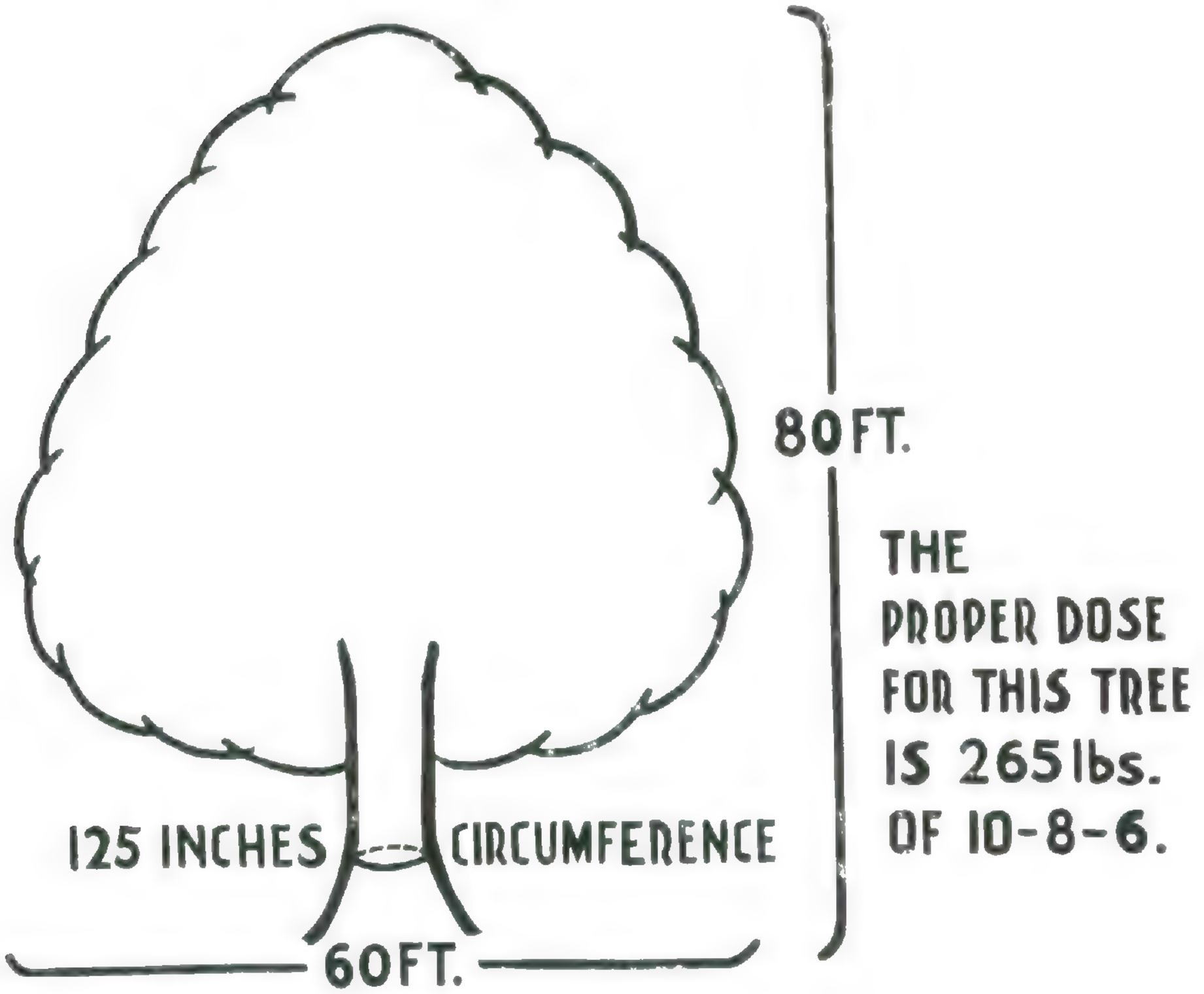


Diagram of pressure feeding gun

There are two major ways of adding fertilizers to the soil. One is to punch holes with a crowbar and fill them with the proper mixture. The other is to drill holes with a soil auger or with hydraulic pressure. Crowbar holes are made under the branch tips and driven from 12–30 inches deep depending upon the depth of the soil. If a single row of holes will not hold all the fertilizer needed another row is made inside or outside of the first. Sometimes it is necessary to perforate the whole area sheltered by the branches

Making holes around tree by punch-bar method

Placing trowel of food in punch-bar hole



How fertilizer dosage is calculated: to the height in feet (80), add the branch spread in feet (60) and the trunk circumference in inches (125). The sum is the amount of 10-8-6 fertilizer needed.

to obtain adequate space. Uusually the holes are about 30 inches apart and the rows spaced tbout 36 inches. If mechanical means are used to drill the holes, the same power is generally used to force the diffusion of the fertilizer through the soil. The home-owner can use the crowbar successfully, while power equipment is usually restricted to professional tree men. A method and the equipment required to do this work with a power sprayer is illustrated. The advantages of the power tools, aside from reducing the heavy manual labor of punching holes, are very real. Either hydraulic or pneumatic pressure used as a carrier will prevent the formation of pockets of fertilizer often attendant upon the use of the crowbar. In the Middle West there are definite advantages in the use of water pressure to carry the fertilizer under ground and force its distribution through many cubic feet of soil. Usually the late summers are dry, and fertilizers require some water for the most effective use. For this reason spring feeding is to be recommended, since trees have a longer season in which to tap this new food supply.

After it has been established that a tree needs more food, the formula has been selected (the 10-8-6 has been generally used), and the method of appli-

Dense forest type
Use ½ calculated dose.

Open-forest, street or lawn type
Use ⅔ calculated dose.

Specimen type
Use full amount.

cation has been decided, it becomes necessary to inquire about the dose per tree. The following three figures have been used to calculate the amount of food to apply to the soil about any particular tree. We have added the height of a tree in feet to the branch spread in feet, and to this added the circumference of the lower part of the trunk in inches. The total has been interpreted as the number of pounds of 10-8-6 fertilizer needed for that tree. This is admittedly a large amount of fertilizer, but it must be remembered that with a starving tree having a branch spread of 60 feet or over we are working with $\frac{1}{16}$ of an acre. If we hope to restore the fertility to a depth of 30 inches (often the depth of root penetration) we are dealing with the equivalent of the top soil of two acres. Field crops often accept 500 pounds of fertilizer per acre and produce prize-winning harvests.

SUMMARY

The need to feed trees is generally accepted since it is not possible to grow either trees or a bumper field crop on the same soil without an attempt to maintain fertility.

Of the many formulas tried during ten years, the 10-8-6 (containing 10 per cent nitrogen, 8 per cent phosphorus, 6 per cent potash) has given the most dependable results.

Fertilizers must be placed within the root area—usually considered to be beneath the branches.

Tree feeding should be done in spring while the soil contains ample water.

Either the crowbar or a mechanical means of placing the food underground may be used. The crowbar pockets permit maximum concentrations but perhaps favor "burning" in very dry seasons.

Follow the dosage suggested for starving trees and reduce the amount if the growth rate is only a little below normal.

RECENT ADVANCES IN WOOD TECHNOLOGY

ROBERT W. SCHERY

Some remarkable developments in utilization of wood have occurred in the first half of the 20th century and bid fair to become increasingly more diverse and important in decades to come. Wood substance can and does make today, in addition to the customary lumber of our homes and furnishings, the multitudinous papers upon which we write, print, and with which we package, and the various rayons of our garments, fire-proof, rot-proof, termite-proof panels for prefabricate construction, plywood of unlimited dimension and plywood permanently molded to specified shape, plastics and plastic-like woods of surprising beauty yet with the strength of steel, alcohol and other chemical compounds, "paper" strong enough to be formed into homes and aircraft, huge laminated arches of specified curvature obviating need of post supports, and many other unexpected inventions of modern technology. With such developments, were our forests able to supply modern America with the superfluity of wood to be had in centuries past, doubtless this very adaptable cellulosic substance could replace steel for most light construction and other purposes of common utility. Profligate exploitation of our once-abundant forests has, however, made large, quality timber so comparatively scarce that raw material with which to fashion the newer wonders of wood is no longer sufficiently cheap and available to undersell products of steel or non-wood plastics. Supply of timber can scarcely be other than short as we pass mid-century, and unless measures are taken now to replenish our growing-stock of trees, the pinch will be felt for generations to come. Prices will doubtless remain high, and methods will be sought for more complete use of what timber we have. Some of the modern trends in making use of what had formerly constituted wood waste are definitely encouraging on this score.

Plywood.—The plywood industry has attained importance only within this century. Most rapid expansion has been had only in the last twenty years, largely because of the development of better glues and glueing techniques after 1930. Plywoods consist of an odd number of thin sheets of

wood (veneer*), rigidly bonded to each other with the grain (direction of majority of fibers or cells) of adjacent sheets at right angles. Each sheet thus reinforces the others, so that the plywood is approximately equally resistant to shear or breakage along either dimension. Modern stamping machines automatically cut out defects in the veneers and glue-in sound wood stamped to the exact size. Smaller and less perfect veneers are coming to be utilized by such techniques, and plywoods of unlimited dimensions can be made by the glueing together of smaller veneers.

More responsible than improvement of veneers for the recent increased utility and demand for plywood is the perfection of the glues or bonding materials. Until only a few years ago plywood was made almost exclusively with the well-known animal and starch glues. These are, of course, not resistant to moisture, and cannot be used out-of-doors, although improved types are quite satisfactory for veneers kept in protected situations. Blood albumen glue was developed during the first world war for use in "water-resistant" plywood, with fair success but poor acceptance because of difficulties in manufacture and complications in application. Casein and soybean glues have in later years given good results under most conditions, but tend to fail under repeated exposure. It remained for the so-called synthetic-resin glues (such as phenol-formaldehyde), only recently discovered, to permit development of water-resistant, high-quality, all-purpose plywood. Such plywood is usually made by the hot-press method, in which alternate layers of veneer and synthetic-resin glue are subjected to heavy pressure (about 200 pounds per square inch) at high temperatures (up to 320° F.) for cure between the platens of the gigantic hot-press machine. The resultant plywood is much used for exposed sidings in construction, for concrete forms, and for many similar purposes.

Molded plywood.—With use of the thermosetting glues, means have been found to mold plywood to compound curvature by "fluid pressure" in autoclaves equipped to create vacuum or high steam or air pressures. During the war years a rapid method of molding synthetic-resin plywood for sections of the famous mosquito bombers was developed. The usual layers of veneer and synthetic-resin were placed about a form and the entire assemblage sealed within a flexible rubberized sac in an autoclave. As autoclave temperatures and pressures rose to set the resin all air was extracted

* Most veneer is made by the rotary process. Large logs are soaked, boiled or steamed to soften the wood, then rotated longitudinally on gigantic chucks against a sharp, stationary knife. The knife slices or peels a thin layer of wood of prescribed thickness, and automatically moves forward this standard distance for each turn of the log. The wood is thus "unpeeled" down to a small core much as you might unroll a roll of paper. Large veneer logs are becoming increasingly difficult to find in the United States. Douglas fir of the Pacific Northwest is at the moment the leading species utilized.

from the rubberized sac, thus pressing the plywood tightly and uniformly against the form. After setting, the molded plywood in permanent shape was simply lifted from its form.

Sandwich panels.—Similar in principle to plywood are the new sandwich panels. Special synthetic-resin glues have been developed to bond metal to wood permanently. The sandwich panel consists of a light core of resin-impregnated corrugated paper or some similar bulky substance, to which is permanently glued facings of aluminum, veneer, etc. The resultant panels are very light in weight, easily handled and assembled, a natural insulator in themselves, and stiff enough to need little or no framing in construction. They have been used in aircraft construction and offer unusual promise for cheap, mass-produced housing.

Stressed-skin construction.—Much on the idea of the sandwich panel is the stressed-skin panel, in which faces of plywood are rigidly glued to a frame of small lumber. A thin "box" results, in which the plywood surfaces support the framework rather than merely being supported by it as in conventional construction. Such panels provide equal strength and stiffness with less than half the weight, size, and quantity of lumber required in conventional procedures. Stressed-skin construction is particularly adaptable to pre-fabricated housing, for which it has already been used commercially.

Plastics from wood.—Wood flour, a finely pulverized form of wood waste, finds much use in certain types of plastics. Mixed with thermosetting resins similar to those used in making all-purpose plywood, it yields bakelite-type plastics. Wood flour can also be used with other adhesives, such as starch, glue, casein, soybean binder, etc., to produce plastic-like substances. The lignin component of wood, freed from cellulose, can serve as a plastic molding powder either by itself or more commonly in mixture with various resins. The lignin may also serve as a binding material for road surfaces, as a linoleum cement, in electroplating, for negative plates of batteries, as a dispersing agent for cement, and for many other common uses. Waste-pulping liquor is an almost limitless source of lignin, but presents considerable difficulty for economical extraction.

Compressed wood.—Highly compressed but otherwise untreated wood is essentially plastic in nature. Under heavy pressures the lignin component of wood is caused to "flow", cementing the wood in its compressed form. A compressed wood called "staypack" has been developed at the Forest Products Laboratory, which shows considerable promise but is unfortunately not resistant to moisture.

Modified woods.—In general, modified woods are formed by treating ordinary wood with thermosetting resins of the phenol-formaldehyde type. It is then cured at prescribed temperatures and pressures, becoming ex-

tremely hard, heavy, and durable. Since it is of like composition throughout, scratches or scars can be buffed out without altering the finish, a factor of particular significance in manufacture of furniture and interior furnishings. "Impreg" of the Forest Products Laboratory is formed in this manner without compression, while "compreg" is the heavier compressed form. Veneer faces of *impreg* are remarkably stabilized against swelling and shrinkage, seldom checking. Both *impreg* and *compreg* are extremely resistant to decay and termite attack, to water and chemicals, and to electrical conduction.

A few other modified woods have been developed at the Forest Products Laboratory. "Staybwood" is wood heated almost to charring under molten metal. Considerable toughness and strength are lost, but dimensional stability and decay resistance are markedly increased. Similar chemical modification can be attained by treatment of wood with certain chemical compounds (such as acetic anhydride or pyridine). The treated wood remains "permanently swollen" due to incorporation of certain radicals in the cell wall compounds, and hence attains a considerable degree of dimensional stability.

Modified paper.—Paper treated with resins of the phenol-formaldehyde type can withstand exposure for protracted periods, and offers promise of a cheap type of all-purpose surfacing. So far most such modified papers have been utilized for electric insulation. A lamellate form of resin-impregnated paper called "papreg" has been developed by the Forest Products Laboratory, for use where mechanical strength is not of first consideration.

Fireproofed woods.—Numerous chemicals which impart fire-resistant qualities to wood have been developed. These may be applied either as a surface coating or in an impregnating solution. Chemicals that have proven particularly effective in impregnation include phosphate or borate salts of ammonium, barium, cadmium, calcium, cobalt, magnesium, and zinc. The day may not be long distant when all construction wood can be cheaply fire-proofed.

Hydrolysis and fermentation of wood.—Chemical alteration of wood waste to products usable in other ways is a field that has shown great promise of late. The alteration is usually effected by hydrolysis (change of cellulose to simpler carbohydrates or sugars by addition of water under proper conditions in presence of dilute sulphuric acid) and subsequent fermentation of the resultant carbohydrates. By using selected fermentation organisms wood substance may directly yield acetic, lactic, butyric, and other acids, methanol, furfural, etc. Hydrolysis and fermentation procedures may be used to grow fodder yeast, to yield alcohol, acetone, butanol, certain glycols and lactic acid. Hydrogenation of the freed lignin

component produces various cyclic alcohols and other industrial solvents, several toxic agents, anti-knock motor fuel compounds, neutral oils, and phenolic compounds.. On the west coast there has recently been erected a large-scale plant to produce grain alcohol from Douglas fir waste by the hydrolysis-fermentation method.

Additional examples of recent developments in wood technology leading to more efficient chemurgic utilization of timber could be given, particularly in such fields as pulping. Doubtless, too, equally significant development is bound to come in all fields utilizing wood waste, as the chemists find new and cheap ways to alter wood compounds to more usable forms. Most of the experimental work along these lines has been carried on at the famed Forest Products Laboratory at Madison, Wisconsin.* The value of this service is readily realized when one considers the diminishing forest potential of the United States, and the increasing necessity for over-all planning to insure adequate forest products for future generations. The United States has too long been tolerant of poor conservation practices with regard to her forests, and inefficient utilization of the timbers they yield.

* Maintained by the U.S.D.A. Forest Service, in cooperation with the University of Wisconsin.

THE FATE OF MISSOURI'S FORESTS

J. A. STEYERMARK

So plentiful were the forests when the early pioneers settled this country, that clearing the land was not only nothing to be concerned about but even a necessity. Gradually, however, the destruction of our forests by burning and cutting became the concern of more far-sighted citizens until state and national forest preserves were set aside and reforestation and forest management were practiced. Although it has taken time, the people of this country are beginning to realize the vast importance of our forest resources for protection of watersheds, prevention of soil erosion, retention of soil moisture and water-table, industrial uses such as lumber and paper, and the esthetic, ornamental, and recreational values.

Despite our realization of the importance of trees, narrow interests are constantly threatening to destroy some of the last remaining stands of beautiful forests, not only in Missouri, but throughout the nation. Witness the fight in past years to save the redwood trees and the present one to retain the unique stand of cloud forest in the Olympic Mountains. Today, our Missouri forests are being despoiled for lumber, as never before, with little concern for saving older seed trees or replanting new stock. Our national forests, fine as they are, actually represent but a small part of the total forest

area to be found in the state. Private holdings are guilty of most management malpractices, and it will take many years to restore forests in numerous sections in the state. What last year was the haunt of song birds, fur-bearing animals, and colorful wild flowers in many parts of Missouri is today a desolate stretch of land, scarred by fire or with wasted remains of tall trunks and branches marring the landscape.

Moreover, hundreds of thousands of acres of forested land in Missouri, valuable for its timber, would be drowned out by the proposed government dams. Can we quietly sit by while beautiful Missouri streams bordered by valuable timber are inundated? Many kinds of trees are highly selective in growth requirements. Those found along our streams and bottom-lands need more moist soil than the ones growing on the uplands. Numerous species that occur along our streams are valuable commercially or ornamentally. They include green, red, and white ash, river birch, wild cherry, bald cypress, American elm, big shellbark hickory, American hornbeam, honey locust, Kentucky coffee tree, linden, sugar maple, various kinds of oaks, Osage orange, pawpaw, pecan, sweet gum, sycamore, walnut, butternut and various willows (black, peached, etc.). Submerge the forests containing this kind of timber, and millions of dollars worth of valuable wood would be destroyed.

Rescue of these forests can only be accomplished by making the public aware of the danger. We must husband such natural wealth as an irreplacable heritage and resist short-sighted exploitation unaccompanied by a long-range program of intelligent management. A sturdy tree, Nature's handiwork of a hundred years or more, can be cut down in a matter of minutes with modern machinery. People of Missouri need to protect their forests against fires, wholesale logging of entire forest sites, and dam impoundments that threaten thousands of acres of forested land. Without forests, it would be a bleak Missouri, indeed.

At tulip time the GRUS AN TEPLITZ rose is worth having for the deep bronze-green of young foliage.

If you would learn the importance of squirrels as foresters, just live near a horsechestnut tree and watch the amazing places where the young seedlings appear after a good seed year.

Science, in the form of 2-4-D, is robbing us of the golden masses of dandelions in our lawns and parks. Let us try and be thankful that the ugly seed stalks are gone as well.

NOTES

Mr. A. P. Beilmann, Manager of the Arboretum, appeared before the Missouri state legislature, at Jefferson City, in April, relative to Resolution 47, which asks Congress to use soil conservation instead of high dams for flood control.

Recent visitors to the Garden include Dr. John Davidson, of the University of Nebraska, and two of his graduate students in botany, Mr. Paul F. Romberg and Mr. B. A. Dixit; Dr. Charles B. Heiser, of the University of Indiana; Mr. Frank Pellett, Editor *American Bee Journal;* Mr. W. W. Collins, secretary Iowa Horticultural Society; Mr. Stuart Ortloff, Landscape Architect, New York.

Through late April and most of May the City Art Museum in St. Louis had on display an exhibition showing the role of *Rosa alba* in the art of the Middle Ages and the Renaissance. This exhibition gradually grew out of an article in the Garden BULLETIN which called attention to the persistence of *Rosa alba* in several old gardens around St. Louis. In connection with the exhibit several old books from the Garden library were displayed, and Dr. Edgar Anderson, Geneticist to the Garden, lectured over Television, on KFUO, and at the Museum on the afternoon of May 2 and the evening of May 9.

Early May brings the delicate gray-white flowers of the Miami Mist *(Phacelia Purshii)* to woodlands and roadsides in the valley bottoms around St. Louis. Often it carpets the ground, almost to the exclusion of other vegetation, with its foamy bloom. Once you have seen the flower through a hand-lens, with all its intricate perfection of fringed petals and spottings and shadings of color, you will wish that the range of your unaided vision was just a little wider.

The Birds'-foot Violet is one of the most variable as well as one of the most beautiful of our native wild flowers. Its large, flat flower may have five petals, all more or less the same shade of gray-blue or the upper ones may be a rich velvety pansy-purple. In these bicolored plants the deep violet varies greatly from plant to plant. There may be streaks or dots of purple on the side petals or it may (very rarely) cover the entire flower. The gray-blue ground color also differs from one plant to another; it may be light or dark, sometimes almost pink, sometimes almost the blue of ordinary violets. The white patch on the lower petal may be slight or it may cover nearly all the petal. The shapes of the petals, too, vary from very broad to quite narrow. Altogether it is hard to think off-hand of another wild flower which has such an engaging variety of form and color.

THE MISSOURI BOTANICAL GARDEN

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SOME FACTS ABOUT THE GARDEN

The Missouri Botanical Garden was opened to the public by Mr. Henry Shaw about 1860. From that date until his death in 1889 it was maintained under his personal direction. Although popularly known as "Shaw's Garden" the name Missouri Botanical Garden was chosen by Mr. Shaw and he definitely indicated that he wished it called by that name. The Garden passed at his death into the hands of a Board of Trustees, designated in Mr. Shaw's will, and the Board so constituted, exclusive of certain ex-officio members, is self-perpetuating. By a further provision of the will the immediate direction of the Garden is vested in a Director, appointed by the Board. The Garden receives no support from city or state but is maintained almost exclusively from the estate left by Henry Shaw. Since 1939 many Garden Clubs and interested individuals have contributed to a "Friends of the Garden Fund" which is used in developing the new Arboretum, located at Gray Summit, Mo. The Arboretum (1) serves as a source of plants, trees and shrubs for the city Garden; (2) affords areas for gradually establishing a pinetum, a wild-flower reservation and various other features on a scale not possible in the city; (3) provides greenhouses for some 20,000 orchid plants.

The city Garden comprises 75 acres, where about 12,000 species of plants are grown, both out of doors and under glass. It is open every day in the year except New Year's Day and Christmas; week days, 8:00 a. m. until 7:00 p. m.; Sundays, 10:00 a. m. until 7:00 p. m. The greenhouses are closed every day at 5:00 p. m.

The main entrance to the Garden is at Tower Grove and Flora Place, on the Sarah bus line (No. 42). The Tower Grove bus (No. 21), direct from downtown, passes within three blocks of the main entrance.

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Missouri Botanical Garden Bulletin

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THE VALUE OF ORGANIC MATTER IN GARDENING

GUSTAV A. L. MEHLQUIST

Probably no component of garden soil has been so controversially discussed as the organic matter. There are some who claim that healthy plants can be grown in media entirely free from organic material, while others go so far as to maintain that plants not only perfect but completely immune to diseases and insects can be obtained if the right kind and amount of organic matter are used. Extravagant and controversial as such claims may be, it is interesting to note that both extremes contain some elements of truth. For instance, normal-looking plants have been grown in sand and other media from which all organic matter has been removed by chemical treatment, all the nutrients needed having been furnished by properly compounded chemicals. In practical gardening, however, such a method is out of the question. Those who go to the other extreme and maintain that the right amount of the right kind of organic matter will eliminate all danger from infectious diseases or insects are not only equally impractical, but, what is worse, their claims are not supported by facts. To be sure, plants grown with the correct amount and kind of organic matter often exhibit a greater resistance to diseases and insects than those grown with an insufficient amount, for the same reason that children who get all the milk, vitamins, and wholesome food that they need will, by and large, show greater resistance to many diseases than will their less-fortunate playmates who get neither sufficient food nor the right kind. It is not my purpose to discourage those who are organic-gardening enthusiasts but to point out that while a sufficient amount of organic matter is desirable for best results in the garden it is not a cure-all. Granted then that organic matter is needed, just what then is meant by that term and how is the material obtained.

Organic matter, in the language of the gardener and soil technician, means the residue from living things. For the sake of convenience, organic

matter may be discussed under three categories: (1) original tissues, such as dead plants, freshly fallen leaves, garbage whenever such is used in composts, grass clippings, etc.; (2) partially decomposed materials such as animal manures, partly rotted leaves, compost, peat moss, and the like; and (3) humus. The term "humus" has been variously treated in horticultural literature. The definition suggested by Waksman seems the most concise and yet inclusive: "Humus is a complex aggregate of brown to dark colored amorphous substances, which have originated during the decomposition of plant and animal residues by microorganisms, under aerobic and anaerobic conditions, usually in soils, composts, peat bogs and water basins." Chemically speaking, humus is largely composed of those parts of organic tissues that are most resistant to decay, the less-resistant tissues having been decomposed before the humus stage was reached. Humus, however, is not a fixed material but is in a dynamic condition as it is constantly formed from plant and animal residues and is continually undergoing further decomposition by microorganisms. Thus the organic fraction of the soil is really the life of the soil.

Organic matter has many important functions in every-day gardening. In the rough or partially decomposed state, organic matter is invaluable for mulching. Proper mulching probably is one of the most useful tricks that the present-day gardener can learn despite the multitude of new things that has become known in the last few years in the fields of plant nutrition and hormone treatments. A 6- to 12-inch layer of leaves, straw, or other undecomposed organic materials is very useful in the winter to prevent frost injury to the surface roots of tender shrubs, bulbs, and perennials. Partially decomposed materials such as leaf mold, compost, manure, peat moss, or ground corn cobs, applied 1–3 inches deep, are exceedingly valuable as summer mulches. This is especially true in the Middle West and Southwest where the rains during the growing season are often limited to the kind of showers that beat down with great force for a few minutes, carrying away much of the best top soil. The intense sun that usually follows literally bakes the exposed roots and forms such a crust on the surface that the next shower cannot penetrate the soil. However, if the soil is cultivated just deep enough to break the crust and a mulch immediately applied, the formation of a new crust is prevented, and water, whether from rain or sprinklers, is able to penetrate. Furthermore, a mulch conserves moisture by cutting down the evaporation from the soil, a very important feature in semi-arid areas. Many people still have the idea that merely breaking the hard crust of the soil will conserve moisture. Experimental evidence indicates just the opposite. To be sure, a hard crust retards water penetration but it also retards evaporation, and merely breaking it up without protecting the loosened sur-

face soil from being washed away by the next heavy rain or beaten into another hard crust is poor economy. Any one who has observed the rivers in the Middle West literally loaded with top soil following a hard rain cannot help but wonder how long this can go on. To those who can read or talk, the dangers from atomic energy seem horrifying, and yet to most people, even those who live directly from working the soil, the yearly irreplaceable loss of soil and the resulting lowered productivity in the face of a continually growing population mean little or nothing. Somehow starvation, either in this generation or the next, does not seem a more pleasant prospect than death from an atomic bomb.

Perhaps the greatest value from organic matter lies in its chemical and physical properties when it is mixed with the soil; that is, when it is part of the complex mixture of materials collectively referred to as the soil.

Physically, organic matter makes for a better structure of the soil. It "opens up" tight clay soils and at the same time "binds" sandy soils. In clay soils the addition of an adequate amount of well-rotted organic matter prevents packing. It therefore creates aeration and tends to prevent cracking and crust formation, thereby stabilizing the moisture-holding capacity of the soil. In light sandy soils, which usually dry out too quickly, the binding and water-holding quality of organic matter is equally valuable.

Chemically, the value of organic matter is perhaps even greater. It has the ability to adsorb various chemicals so as to change the amounts of inorganic salts going into solution and to form compounds with certain elements, notably iron, which render them more readily available to plants. This quality manifests itself in so-called buffer action which may be defined as the ability to resist change; that is, when a dose of fertilizer is added to a soil low in organic matter most of this fertilizer becomes immediately available to the plant, which is all right provided only the right amount and kind of fertilizer are applied at one time and more is added as this is used up. However, since we do not know exactly what kind of fertilizer is required nor how much, an overdose may be directly injurious. On the other hand, a soil rich in organic matter adsorbs much of the fertilizer which, after undergoing many changes, is slowly released through the process of decomposition to the plant roots in available form. Thus organic matter not only tends to prevent injury from overdoses of fertilizer but also to reduce the losses of soluble fertilizers from the soil through leaching by heavy rains, quite a factor in some soils.

Biologically, the organic matter serves as a source of energy for microorganisms which, under proper conditions, are responsible for converting many of the non-available chemicals and minerals into available plant nutrients. The microorganisms obtain the energy by decomposing the organic

matter. During this process ammonia, carbon dioxide, and water are released as by-products. The carbon dioxide is released into the air from which the plants again absorb it through the process of photosynthesis. The ammonia is changed into nitrates, the form of nitrogen most readily available to the majority of plants. The water is utilized directly by both microorganisms and plants.

The question naturally arises what is the best kind of organic matter to use and how is it obtained. The answer to this question depends on many local conditions and can be answered here only in a general way. No matter where a gardener is located he usually has access to fallen leaves, grass clippings, and plant refuse of various types. As has already been pointed out, leaves and other coarse material can be used directly as winter mulches. With shrubs and larger perennials it is not necessary or even desirable to remove this material in the spring. It can be spaded in or just left to serve as a summer mulch. If this is not possible because additional plants are to be planted the material should be raked off and put on the compost pile. When undecomposed organic matter is mixed with the soil just before planting time, the plants often develop symptoms indicating lack of nitrogen. This is due to the fact that the microorganisms, in decomposing the organic matter, build up their own numbers very rapidly and in so doing take away some of the available nitrogen from the soil. A light application of a readily available nitrogenous fertilizer will give both the plants and the microorganisms enough nitrogen, and as the organic matter is decomposed the nitrogen removed by the microorganisms is returned, so the loss is only a temporary one.

For best results the organic matter that is to be mixed into the soil should be pretty well decomposed. To accomplish this it should be properly composted. As with most horticultural subjects, the methods recommended for composting vary with the author. This is not so disturbing as it may seem, for local conditions and materials often dictate variations in procedure. Any kind of organic refuse can be used in making a compost pile—leaves, weeds, grass clippings, garbage, etc. Straw or hay used for winter protection of roses and perennials, and even smaller evergreen branches and twigs can be used. A word of warning, though—unless the compost pile can be made large enough to develop sufficient heat to destroy diseases and insects, diseased and insect-infested plants should be burned rather than put into the compost pile. The size of pile required to develop this heat (around 145–150° F.) varies with the material used, coarser materials requiring greater depth than finer materials. For average materials the pile should be not less than five or six feet wide and as high. The length of the pile will depend on the amount to be composted, but, of course, should not be less than the width. After decomposition the material will have settled to less than half that height. It

should be borne in mind that since little or no heat is developed on the outside of the pile, the outside material should be spaded inside when it is turned over so as to heat it up sufficiently to pasteurize it. More rapid decomposition will take place if an inch or two of animal manure and garden loam is added for every foot of organic refuse. The addition of balanced commercial fertilizers, at the rate of three to five pounds per 100 cubic feet, will also greatly hasten the decomposition.

A comparatively level, shaded, out-of-the-way place is the best location for the compost pile. If a variety of materials is used, they should be mixed or laid in thin layers, one on top of the other, to a depth of a foot, and then covered with manure and soil as mentioned above. Five or six successive layers make a suitable depth for most materials. If neither soil nor manure is available, a balanced commercial fertilizer may be applied at the rate of three to five pounds per 100 square feet of the individual one-foot layers. If heavy stalks such as those of corn, sunflowers or hollyhocks are used, they should be laid across the pile, preferably in the lower layers. In this manner they will facilitate proper aeration as the pile sinks and packs due to decomposition. The pile should be laid with the sides as straight as the material will permit and the top should be depressed to catch and hold the rain water. If the material is dry at the time of making the pile it should be watered, or if it dries out later it should be watered from time to time. After six to ten weeks the pile should be turned over with a fork and the outside material put on the inside, and in another six to ten weeks the compost is ready for use. If mainly oak or beech leaves are used for composting, agricultural limestone should be used at the rate of five pounds per 100 cubic feet in order to neutralize some of the acidity inherent in these leaves. Lime should not be added, however, if the compost is intended for acid-loving plants such as Azaleas and Rhododendrons. An acid compost will require longer to break down, often a year or more.

Any one interested in soils and composts will find the following references interesting and helpful:

The Nature and Properties of Soils, by T. Lyttleton Lyon and Harry O. Buckman. The Macmillan Co. 1947.
Soils and Fertilizers, by Firman E. Bear. John Wiley & Sons, Inc. 1947.
Humus, by Selman A. Waksman. Williams & Wilkins Co. 1938.
Our Plundered Planet, by Fairfield Osborn. Little, Brown & Co. 1948.
An Agricultural Testament, by Sir Albert Howard. London. 1940.

A common native tree which provides food for birds is the Mulberry. Cedar Waxwings particularly seem to enjoy the fruit. Strangely, the fruit is little used for human food in North America, but in southern Brazil it is much esteemed.

SOIL MICROORGANISMS, EARTHWORMS, AND MAN

ROBERT W. SCHERY

We human beings like to think of ourselves as the most highly evolved of all organisms, big or little, vegetable or animal, living or dead; and indeed, man with his God-granted mind, bent now on construction and now on destruction, is a creature the like of which has never before manifested so profound an influence upon this world. But many a creature of a much more humble stature, often primitive and unchanging, usually boasting a span of occupancy in this world a thousand-fold that of man, works with man that he may continue to inhabit the face of the earth with his many non-nomadic peoples and great cities. It is usually such small organisms, working with nature, that help build and keep soils, and thus permit an agriculture which utilizes for man's benefit most of the land area of the world and much of the sunlight reaching it.

Green plants alone are able, from air (carbon-dioxide), water, and a few soil minerals, to build up foods in quantity. To do this they must capture the energy of sunlight, by means of that extraordinary green pigment called chlorophyll. Ordinarily, air is sufficient, water is plentiful, and sunlight is abundant enough to make plants grow well. It is, then, the quality and quantity of soil minerals and their availability to the plant that most often decide the difference between good or poor plant growth, between good and poor harvest. The suitability of the soil and its quantity and quality of minerals are largely dependent upon the numbers and kinds of small organisms growing in that soil. And thus it follows that the "carrying-capacity" of the land is to a great extent contingent upon these small organisms and whether or not they thrive.

All living creatures must depend for their energy (i.e. food) upon the mantle of green worn by the earth. If more energy (food) is needed by animals occupying a given area than can be accumulated by the plant cover during the growing season, some of these animals must move elsewhere, or, alternatively, die. The carrying capacity of any area varies for the type of animal considered. Under normal conditions one-third acre may support a rabbit; perhaps a full acre is needed to keep a quail; hundreds of acres will be needed for a wolf or mountain lion. Under conditions of modern agriculture man seems to need two to three acres per individual in order to maintain a standard of living commensurate with modern needs. In certain crowded parts of the world, such as India, China, and parts of Europe, this specified acreage per individual may not be met, hence either some or most of the population exists at a miserable standard of living, or acreage is "borrowed" elsewhere (i.e. through imports in exchange for work—an industrial

economy). It is conceivable, should world population keep growing and/or soil be let deteriorate, that some day in the not-too-remote future man will find he has exceeded the carrying capacity of the earth—that, even at the expense of all other organisms, he must demand more energy than a world of green plants can accumulate for him.

There is tremendous competition for this energy snared from sunlight by green plants, and perhaps the most reckless exploiter of it is man. Man and the earthworms and the microorganisms share among them far the greatest portion of all energy (food) accumulated by green plants, but whereas earthworms and microorganisms in exchange for energy break down complex foods and return the simpler end-products to the soil for use once again by green plants, man usually carries his away and ultimately dumps the end-products (sewage) into the ocean, giving little back to the soil and the future.

Individually earthworms use little energy. Individually microorganisms (bacteria, molds, yeasts, protozoans, etc.) need even less. It is only because both categories are so frequent in the soil that the cumulative energy needed becomes quite significant. Experts estimate that the population of earthworms may average 125,000 to an acre, utilizing as a group more than 200 Kg. Cal. of energy per acre per day. There may be 3,000,000,000,000,000,000 microorganisms to the acre, utilizing altogether 2700 Kg. Cal. of energy per acre per day. And man, living at a modern standard of living, with a population density equaling that of a northeastern state, drawing, of course, upon energy stored long ago by plants of an ancient era (coal) presumably squanders about 6000 Kg. Cal. of energy per acre per day. Thus man becomes the greatest profligate of our energy supply. And green plants are believed to capture only 16,000 Kg. Cal. of energy per acre per day, and this only during the growing season.

Man, in order to meet his energy needs from the acres he cultivates, must maintain optimal plant growth. To do this he must allow to accumulate on or to "feed" back into the soil the equivalent of food minerals that he consumes (removes). He can do so partly by adding chemical fertilizers, but chemical fertilizers are not nature's way and will not alone make a soil the dynamic system needed for best crop production. Organic matter (humus) is needed to give proper tilth or structure, as well as to supply nutrients through decay. Organic matter is "consumed" or acted upon particularly by earthworms and microorganisms, which alter and eventually break it down into materials usable by plant roots. It serves as a huge "plant food" reservoir in the soil, holding and releasing needed mineral materials. Earthworms and microorganisms need this organic matter; only by decomposing or digesting it can they obtain their share of that energy built into organic molecules by green plants.

Earthworms of a number of species inhabit most soils of the world. They "eat" their way through the soil, swallowing all and digesting at least partly the organic matter contained. Thus do they secure energy needed to live. While so doing the worm's digestive juices act not only upon organic matter, but even mineral components may be altered or broken down into products more conducive to a fertile soil. Soils are mixed by earthworms (Darwin believed $\frac{1}{10}$–$\frac{1}{5}$ of an inch of soil to be brought to the surface yearly by these creatures), with perhaps as much as 15 tons of soil per acre passing through the intestinal tract of earthworms annually. Then too, worm burrows allow rain and air to penetrate the soil layers, and organic debris from the surface may be dragged to lower soil levels. That earthworms may be beneficial or at least not harmful to the soil is suggested by the fact that their frequency usually correlates with the quality of the soil. Soils rich in organic matter, such as those to which farmyard manure has been applied, are also heavily populated by earthworms. In very rich soils there may be an half-ton of earthworms to the acre. A number of "earthworm farms" now exist, advertising and selling earthworms for the inoculation of compost heaps and garbage piles. An active earthworm population can reduce such refuse to fine earthy humus within a few weeks.

The microorganisms of the soil are exceedingly diverse and complex. In general, they subsist by digesting or breaking down the large, energy-rich molecules of which plant and animal tissue is built, thereby obtaining for themselves the energy that was put into construction of such molecules during green plant photosynthesis. This is decay, a process of extreme importance to the living world. In effecting decay the microorganisms free to the soil, once again, elements derived from the soil that are temporarily isolated and uselessly tied up in (now dead) plant and animal tissue. Most soil microorganisms are beneficial, and anything that man does to increase their frequency will generally be a boon to the soil. Especially should man see that soils have some organic content to be productive; especially should he see that organic matter be not wantonly destroyed and microorganisms killed, as may occur with repeated burning-over of forest or field.

Perhaps the most important soil organisms are the bacteria (other important groups from the vegetable kingdom include various fungi, often macroscopic and mushroom-like; algae; Actinomycetes; and plant roots themselves). Bacteria are ordinarily envisioned as inimical to mankind, causing many of man's diseases and spoilage of his food. However, this same group of microorganisms also does much to replenish the fertility of our soils. A bacterium is just one cell—not big enough to be seen with the naked eye—but it reproduces unbelievably rapidly. Often a number of these organisms remain together in characteristic colonies. Structurally they are very primi-

tive, lack sexual features, and may or may not be capable of motility. They frequently are best known for the reactions they cause—e.g., in breaking down complex organic molecules whether they do or do not produce a certain acid.

The family Nitrobacteriaceae is of great significance in soils. Certain bacteria of this group can oxidize nitrates, methane, and ammonium into forms more usable by higher plants. The group is peculiar in that it does not always need complex organic molecules for energy, but instead derives energy from such oxidations as have been indicated. In the family Rhizobiaceae we find bacteria that are able to take nitrogen from the air and change this inert gas into a form usable by higher plants. Such bacteria usually live in nodules on the roots of plants of the pea family. They are extremely important in renewing the usable nitrogen supplies of the soil. Functioning much like the Rhizobiaceae but not living on roots of pea family plants are the Azotobacteriaceae. They likewise are nitrogen replenishers for the soil. Also many other groups of bacteria, along with Actinomycetes and other fungi, benefit the soil through decay, liberating vital elements tied up in the large organic molecules.

Earthworms as an animal-kingdom contribution to soil dynamics, and bacteria as representative soil microorganisms from the plant kingdom, working (albeit unknowingly) for the benefit of higher plants and animals, offer a striking example of the intricate interconnections of nature, Darwin's "web of life." That which may alter the existence of these inconspicuous and lowly creatures ultimately affects mankind. The world of living organisms is "one world" as truly as is man's political world of such concern today. Man may at this brief moment of earth history dominate the world, but if he is to maintain his position, and what is even more important, if he is to progress for his own good, he must work with nature and nature's beings, not against them.

WILDNESS

A Succession of Events on Gravois Creek

ALFRED G. ETTER

In spare moments I am occasionally entertained by the vision of a clear creek and a spring feeding it through a green tongue of crisp watercress. Along the bank are camped in comfortable disarrangement wagons of gypsies. Their shaggy horses stand silent and black beneath the deep shade along the stream. This vision is now undoubtedly embellished with the romance of time past, but the realness of the scene is unmistakable. It is a memory of the Saturdays when some of us, as children, used to come with a lunch of sandwiches

to Gravois Creek. There at the spring we would wash away the heat of tramping along country roads, and we would drink, from the pale blue mirrored pool, water which was magic and good.

Tall sycamores and elms still tower above the valley in a few protected places.

We seldom allowed our backs to turn upon the gypsies, for they were dark people of somewhat unknown nature, imbued with the mystery of much childhood fantasy. And so, while we walked the woods, picking violets or sweet-william or buttercups that grew in the spongy black mold, or waded in the stream and sought snails, mussels, and silver bream, or as we stood surrounded by a copse of wild crab, or leaned on the trunk of an old redbud as the early spring sunshine filtered down through the canopy of trees, we enjoyed the vague danger of gypsies. Along the streams were sycamores so large that they encircled whole meanders in the palms of their roots. Wild grape vines, tangled in the branches, hung to the ground and gave us a brief new power of touching the high, otherwise remote, limbs of trees. And there were banks of moss, deep green and soft; and fallen, fractured rocks supported ferns and made innumerable cavities where animals could live.

The childish reverence for a place of gathering flowers was our possession, and we seldom took the trip home through the dusty roads that lived so intimately with the bordering fields without a handful of clean green violet stems clutched firmly, the coolness of the petals brushing our hand. And yet the secret enjoyment of such bouquets was that they had been gathered in the gypsies' woods. Our pride in this was great and full of grave significance.

Sawdust smoldering across from the sewage-disposal plant—Gravois Creek for the new generation.

It was never clear to me as a child exactly why we gradually forewent this pleasure. It is strange to realize the full story now, after nearly twenty years have passed. The road by the creek that squeezed between the trunks of trees and almost lost itself with turning slowly disappeared as the years went by in rank lanes of nettles and became a source of painful lessons learned. The gypsies were not seen any more, and the silent old horses that had lent so pungent an odor to the camp no longer rubbed themselves against the worn trunk of the sycamores. The search for mussels and minnows was a dangerous and unprofitable one in the now slippery and cloudy stream. Moss (I would have to call it algae now) was growing heavily on the gravel, and the smell that rose from the water on a quiet sunny day was unpleasant. The violets were there, and the buttercups, but the blue crystal of the spring had broken and we were forbidden to drink from it. The sewage of suburbs now made the name of Gravois Creek more famous for its odor than it had ever been for its gypsies or its flowers or clear water.

A suggestion of the beauty of the creek still remains, if we can hold our breath.

I suspect that the construction of a broad concrete highway through this area had as much to do with the disappearance of the gypsies as anything else. Though we are inclined to look upon good roads as the means for making areas accessible, for the horse-wagons of the gypsies they became impassible barriers to long uninterrupted days of journey along quiet rural roads.

The highway soon enticed a lumber mill which set up its saws in one of the flats of the creek. With it came the shacks of workers, crowded along the stream banks. Junk accumulated in the creek: old bedsprings, Ford chasses, tin cans, mattresses, rags, bottles, chicken feathers. Stacks of lumber and barrel staves grew, feeding on the trunks of white and black oaks from the hills, the sycamores of the valleys. Sawdust towers were built to the memory of Gravois woods. Skinny children played in the creek bottom, catching the few remaining crawfish, throwing mud at the emerald dragon flies. Then a nurseryman bought the spring and bricked it in for irrigating his platoons of evergreens. Billboards and tourist cabins have since completed the annihilation of this peaceful scene.

The secret beauty of the valley, however, still exists in my mind. But the gypsies with their mysterious wagons and their smoking fires, the crystal spring, and cool violets are gone. If I tell my son I knew these things, he will scarcely believe me. There is no evidence remaining. I often wonder where my child can go to learn what this earth was like before he was born.

Reality changes as fast as that. If he is to worship God, what love can be built on a repulsive creek, a bricked-in spring, the amorphous trees that slump in the abandoned sawdust pile beside the squatters' galvanized roofs? My dim memory of these childish things can never let him know the soft mystery of gypsies camping on a stream, and tales of flowers gathered in their woods will not make nettles sting the less. Science so far has devoted itself to many fields, but up to the present has never concerned itself with the preservation of simple beauty and landscapes for the creation of childhood memories. At the same time, artists and illustrators continue drawing colorful pastoral scenes rich in flowers and animal life as decorations for children's stories. Psychologists have from time to time condemned fairy stories for the illusions and complexes that they build up in the minds of children. What complications then will arise, or are arising now for that matter, from the use of peaceful country-sides and profuse floras and faunas in the child's book? Certainly there is no greater illusion for the city child than the idea that such scenes are enduring, well-taken-care-of parts of the world in which he is growing up. Personally, I am not inclined to believe that the neglect which these matters have so far received is indicative of their importance in a society destined to become more complicated and unnatural.

City children have no concept of wildness, of the rhythm of natural events, of the significance of non-human forms of life, of the inter-relationships of living things and the land. At the same time present and future generations are faced with the very difficult problems of dealing sensibly with matters such as river and stream control, erosion control, human nutrition, and prevention of diseases, both physical and mental, resulting from abnormal developments in modern society. Even a brief consideration of these problems demonstrates the need for a public familiar with the land and conscious of the existence of natural laws. If, as children, adults have had contact with the beauty, peace, organization, or thrill of wild plants and animals in their natural habitat, it will be that much simpler for them to understand problems involving man and his own environment.

Highways radiating from the city gradually force wild places into the distance, and the quiet of country lanes is forgotten in the thrill of speed. Gardens and parks try to preserve little fragments of vegetation and animal life. Hundreds of miles away there may be a preserve or national park, but for the average city child, and for many country children for that matter, these places are inaccessible. Rare indeed is the opportunity for people to become a part of a natural scene and to look with wonder and astonishment at something which is not man-built, something which represents a power greater, by far, than their own.

Gravois Creek, with its woods and wildflowers, was not only *my* retreat

Shacks and trash-dumps border the creek in the very shadow of the gypsies' trees.

The big oaks were cut and taken to the lumber mill—the smaller trees are now being cut for firewood.

but provided pleasure to many families. Now, as a sewer it breeds repulsiveness and disease. Earlier in the city's history the River des Peres was a beautiful spring-fed stream. Now it is a sluiceway for waste. Many other drainages have met a similar fate. Is it inevitable that every watershed unfortunate enough to be caught in the expansion of a city meet a similar fate? I myself see no reason why it should be. During the war, while stationed in Washington, D. C., I enjoyed many pleasant walks through a wild valley that has been preserved at the edge of the city. Perhaps there are other examples from other cities. I do not know. I only wish that there could be one or more in every city, in the life of every child.

Not uncommonly when strolling along a wooded path or boating down an Ozark stream at this time of the year, one will smell a pervading fragrance with no visible flower source. In most cases it will be that of the wild grape flowers—inconspicuous in themselves and furthermore borne on vines that usually trail high over the brush or near the tops of trees where the inflorescence is difficult to see. Interestingly, the five petals of the flowers fall off together as a small cap. Those who were on Missouri's rivers over the Memorial Day week-end may have noticed a yellow-green "dust" of these miniature bowls or caps floating atop the water—a "scum" not objectionable when the source is realized.

The season when blue-grass approaches a state of dormancy awaiting the cool moist weather of autumn is almost upon us. It is a season when homeowners with lawns of blue-grass will not have to mow more than every second week or so, but others with lawns of crab-grass will have to keep the lawnmower active throughout the heat of July and August. Blue-grass should not be clipped close during this period and should be sprinkled infrequently but thoroughly (to several inches depth). One way to encourage blue-grass and discourage crab-grass is not to mow the blue-grass. The blue-grass, getting an early spring start, tends over a period of years to shade out the later-starting, annual crab-grass.

NOTE: Due to an oversight figs. 1–3 and 6–7 of Mehlquist's paper on "Delphiniums" in the April BULLETIN were not credited to Bodger's Seeds, Ltd., of El Monte, Calif.

NOTES

Dr. C. W. Dodge, Mycologist to the Garden, has been appointed Visiting Professor of Botany for the summer months at Louisiana State University, where he will lecture on medical mycology.

Mr. Robert Baxter, graduate student in the Shaw School of Botany who received his doctor's degree in June, has been appointed Assistant Professor of Botany at the University of Kansas, Manhattan, for the coming year.

Mr. George H. Pring, Superintendent of the Garden, attended the meeting of the American Orchid Society, in New York, May 23-24, and on the afternoon of May 23 conducted a symposium on orchid growing.

The May number of the ANNALS OF THE MISSOURI BOTANICAL GARDEN, consisting of Fasc. 5 (fourth and concluding part of the Orchidaceae, by Paul H. Allen) of Part III of Woodson & Schery's *Flora of Panama*, was issued during the month.

The annual flower sermon, provided for in the will of Henry Shaw, was preached at Christ Church Cathedral, on Sunday, May 22, by the Rev. Charles W. Gilkey, until his retirement Dean of the Chapel at the University of Chicago.

Recent visitors to the Garden include: Mrs. Iva Newman, rose enthusiast, of San Mateo, Calif.; Dr. George B. Happ, of Principia College, Elsah, Ill.; Mr. Eric Kristensen, of Kolding, Denmark; Prof. T. H. McHatton, of the Department of Horticulture, University of Georgia, Athens; Mr. U. Aung Myint, of Rangoon, Burma, now a student at the Colorado School of Mines, Golden, Colo.

Among the groups visiting the Arboretum during the month were the Girl Scout Leaders of St. Louis; the biology class of Principia College, Elsah, Ill.; the students in forestry from the University of Missouri, Columbia, accompanied by Prof. R. E. McDermott; and the students in floriculture from the University of Missouri, accompanied by Prof. J. E. Smith, Jr.

The Boatmen's National Bank, whose aim is to promote civic pride in St. Louis organizations and industries by means of exhibits in their windows, will feature the Missouri Botanical Garden during July and August. The windows on Olive and Broadway will display the various Garden activities such as conservation, research, plant exploration, desert plants, rose growing, orchid breeding, etc., and a showcase inside the building will contain books typical of each century from the 15th to the 20th century, to show the development of botanical illustration.

THE MISSOURI BOTANICAL GARDEN

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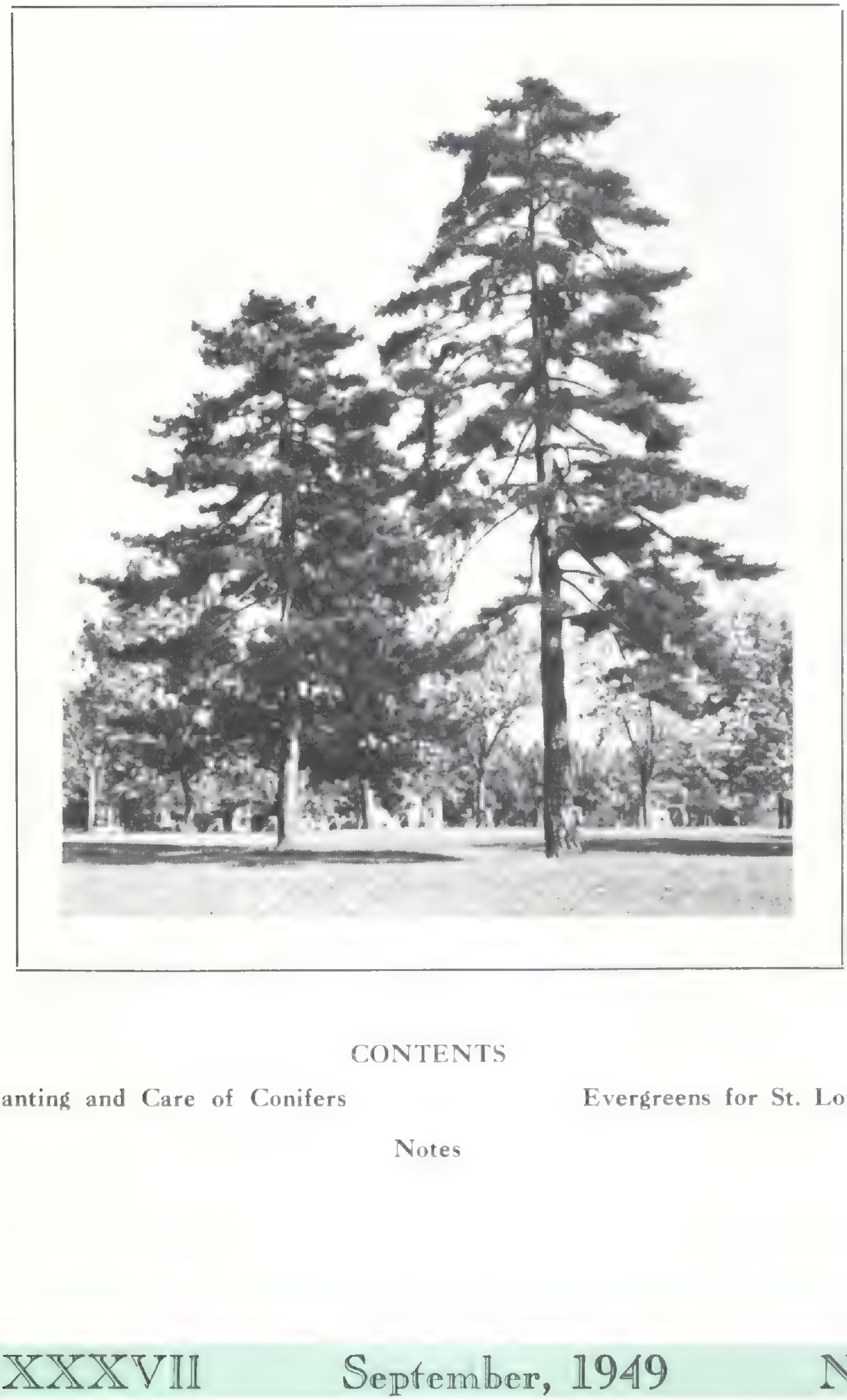
SOME FACTS ABOUT THE GARDEN

The Missouri Botanical Garden was opened to the public by Mr. Henry Shaw about 1860. From that date until his death in 1889 it was maintained under his personal direction. Although popularly known as "Shaw's Garden" the name Missouri Botanical Garden was chosen by Mr. Shaw and he definitely indicated that he wished it called by that name. The Garden passed at his death into the hands of a Board of Trustees, designated in Mr. Shaw's will, and the Board so constituted, exclusive of certain ex-officio members, is self-perpetuating. By a further provision of the will the immediate direction of the Garden is vested in a Director, appointed by the Board. The Garden receives no support from city or state but is maintained almost exclusively from the estate left by Henry Shaw. Since 1939 many Garden Clubs and interested individuals have contributed to a "Friends of the Garden Fund" which is used in developing the new Arboretum, located at Gray Summit, Mo. The Arboretum (1) serves as a source of plants, trees and shrubs for the city Garden; (2) affords areas for gradually establishing a pinetum, a wild-flower reservation and various other features on a scale not possible in the city; (3) provides greenhouses for some 20,000 orchid plants.

The city Garden comprises 75 acres, where about 12,000 species of plants are grown, both out of doors and under glass. It is open every day in the year except New Year's Day and Christmas; week days, 8:00 a. m. until 7:00 p. m.; Sundays, 10:00 a. m. until 7:00 p. m. The greenhouses are closed every day at 5:00 p. m.

The main entrance to the Garden is at Tower Grove and Flora Place, on the Sarah bus line (No. 42). The Tower Grove bus (No. 21), direct from downtown, passes within three blocks of the main entrance.

MISSOURI BOTANICAL GARDEN BULLETIN



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Cover: Black Pine *(Pinus nigra* var. *austriaca)* in Forest Park. Photograph by Gloria Kuykendall.

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Missouri Botanical Garden Bulletin

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PLANTING AND CARE OF CONIFERS

AUGUST P. BEILMANN

As with many other biological problems, it would be very difficult to formulate hard-and-fast rules guaranteeing success with evergreens. As an example, we might cite the years 1930 to 1936 when the primary requirements were irrigation and the heaviest kind of mulch to prevent evaporation. The other extreme was reached in 1949 when all the moisture requirements were automatically met by continued rains and the high humidity. During this past summer little irrigation was required, and mulching, while always beneficial, was not nearly so important as it would have been in a dry year.

Perhaps by beginning with some basic needs we can arrive at some general rules for the planting and care of evergreens. First of all, they require a great deal of soil moisture. The largest conifers are always found in regions of heavy rainfall, fogs, and high humidity. As we proceed inland from both coasts and southward toward the Middle West, all conifers disappear with the exception of the juniper which can stand the greatest amount of exposure. The Southern Pines are found in mountainous regions and along the southern coasts. In these areas the amount of rainfall is greater and conifers are again present in profusion.

In the Middle West, irrigation may be required to supplement moisture requirements in a year of normal rainfall. Unfortunately, conifers give no warning of their need for moisture, unlike deciduous trees which usually indicate their distress long before death. The conifers appear to be growing well until the day the needles are shed. It is then too late to add water since the tree has been virtually dead for about thirty days. The need to conserve moisture is demonstrated in coniferous woods where the heavy layer of needles becomes a ground cover to check soil evaporation. It is necessary that some mulch be available after planting. Rotted stable manure

is the very best, then leaves and leaf mould, grass clippings, and hay. Even sawdust is quite satisfactory, used either fresh or partly rotted from hardwood mills.

Although the conifers are frequently found on land that is worthless for agriculture, it does not follow that they will flourish when planted in such places. Like most other plants, they will always do very much better on good soils. They usually grow faster in the Middle West if given some protection from the worst of the heat and the winds. Some conifers will stand much shade in youth, but all of them enjoy full sunshine after being established. We may single out certain species and elaborate on their specific requirements. For instance, junipers will stand the maximum exposure to sun and wind but do better on good soil under heavy mulch and seem to like being planted close to limestone rocks. The hemlocks must have a fertile damp soil and complete protection from the south and southwest winds. Yews prefer to be left alone after planting. They require no cultivation, but enjoy a heavy mulch and do not object to competing weeds. The spruces will grow just as long as fertility and moisture requirements are met. The pines can stand more abuse than the spruces, but their life span is also proportionate to the fertility and moisture of the soil.

Normally, the conifers can be transplanted after August 15, and in the Middle West this is a better time than spring planting. A great deal of root growth takes place in the late fall and early winter. Evergreens of almost any size can be successfully transplanted. There are some recorded instances in which mature specimens, properly balled, were moved with machinery capable of handling the fifty tons of soil, roots, and trunk.

The conifers are almost always planted with a ball of roots and soil wrapped in burlap. Only the smallest seedlings, under forestry conditions, can be successfully planted with bare roots. Ordinarily, the weight of the soil in the ball is far greater than that of the plant. For this reason the planting of evergreens usually involves much labor and more than the usual amount of time for other trees. The size of ball required for a particular tree varies with the practices of the nursery from which it was obtained. Frequently the ball of earth is calculated as one foot in diameter for each inch diameter of trunk. This figure may be adequate for nursery-grown trees, but less than half enough for forest seedlings. Since the size of the ball has been established by the nurseryman it is not difficult to dig a hole of the proper size. The rule here is the same as for any other plant. Make the hole as big as you possibly can, backfilling with good soil. Too many evergreens are killed by deep planting. To avoid this, dig the hole no deeper than the depth of the ball, but dig it much greater in diameter and fill it with the best soil obtainable.

After the plantings have been established it is necessary to maintain the needed fertility. Mulching will add plant food, but as the trees grow additional fertilizer may be required. One can use almost any of the shade tree fertilizers but conifers respond very well to organic fertilizers. A heavy application of disposal plant "sludge" such as Milorganite will help maintain vigorous growth. The plants should not be allowed to deteriorate with the expectation of feeding them heavily at some future date, but a little fertilizer should be added annually along with the mulch.

Ornamental plantings of conifers are not frequently attacked by diseases in this area. Usually the decline and death of a plant are due primarily to some cultural practice. Frequently, some diesases can be found, but their control and the identification must be left to the specialist. Insects prove troublesome in many years, but, with modern materials and equipment, control is usually no problem. In a plantation of any size arsenate of lead should be applied about May 15 for the control of the bagworm. At this season the larvae are very small and readily controlled by arsenicals. Later red spider may be a problem, and D.D.T. should be applied at the first indication of trouble caused by these mites. Eventually, of course, ornamental plantings in the Middle West will be attacked by many other insects, but at the present time only the bagworm and the red spider are likely to be troublesome.

SOME EVERGREENS FOR ST. LOUIS GARDENS

J. RICHARD KUYKENDALL, DAVID O. GALEY, AND ROBERT GILLESPIE

Until the enforcement of the smoke ordinance in 1940, it was possible to grow only a very few smoke-resistant conifers in St. Louis gardens. In 1941, an article entitled "Evergreens for St. Louis"[1] was written in response to the increasing interest in planting evergreens which could not previously be grown here because of the smoke conditions. Since there was very little experimental evidence available regarding suitable evergreens for the St. Louis area, some of the recommendations made in that article were necessarily of a tentative nature.

Aside from the smoke problem, another very important factor, climate, must be taken into consideration in determining which coniferous evergreens may be grown successfully. Most conifers are native to regions where the climates differ greatly from ours, and although some of them may grow well for some time after being planted in this area, they may suddenly die after

[1] November, 1941, Garden BULLETIN.

ten or fifteen years. There is thus need for a long-period trial to learn which types of trees can best be used in city gardens. To quote from the 1941 article mentioned:

> . . . Every region therefore needs a big arboretum as a proving ground for evergreens. From such an arboretum can come authoritative recommendations as to which evergreens to plant for immediate effect and which can be relied upon to increase in beauty and dignity with each decade.
>
> The Missouri Botanical Garden, realizing the need for just such information, did start a pinetum as soon as it established its new arboretum outside of the smoke zone. That was only fifteen years ago, and while the oldest plantings are already beginning to put on an air of maturity, it is still much too soon to make definite recommendations for this region. . . .

In the eight years since the article quoted was written an ever-increasing number of conifers has been planted in our city gardens and parks. It has been twenty-three years since the experimental pinetum was established at the Arboretum, and the experiments which were in progress in 1941 have now been carried to the extent where more definite recommendations can be made. In the following list of conifers which are commonly planted in this area, the suggestions and criticisms are based primarily on the results of experimental plantings at the Arboretum.

Pines

White Pine *(Pinus Strobus)*.—This five-needled pine is native to North America and is perhaps the best of the pines for the St. Louis area. Although somewhat loose and ragged when very young, it becomes a large tall tree with a graceful, majestic shape. It is noted for its long, soft, blue-green needles. It stands transplanting well, grows rapidly, is drought-resistant, and does well even in rather poor soils. This "King of the Pines" is noteworthy in that it retains its lower branches even at maturity.

Japanese Black Pine *(Pinus Thunbergii)*.—This oriental pine has proved to be a very good tree for St. Louis. Because it sometimes looks rather wind-blown, with the main stem tending toward a horizontal position, it may be used where a unique or bizarre effect is wanted. An open place where it will not be crowded is best, and it has proved to be drought-resistant and a hardy, rugged grower. The new spring growth is very attractive, making the tree appear as if covered with tallow "candles." The needles are longer and stiffer than those of the Japanese Red Pine.

Japanese Red Pine *(Pinus densiflora)*.—The Japanese Red Pine closely resembles the Japanese Black Pine. Its needles are a soft yellow-green and held at different angles on different branches, making the tree look rough and unkempt. After about thirty years, it assumes a very ragged appearance.

White Pine *(Pinus Strobus)*.
Probably the best pine for the St. Louis area.

Canadian Memlock *(Tsuga canadensis)*.
A good evergreen for background planting or a lawn specimen.

AUSTRIAN PINE *(Pinus nigra)*.—This very close relative of the Black Pine of Europe can be highly recommended. Since it is drought- and smoke-resistant it sometimes outlives the White Pine in St. Louis. Being able to stand full exposure and needing no special attention, it can be planted either in sheltered or open locations. The foliage makes a dense screen when the tree is young, so it can be used for specimen or background planting equally well. It grows very rapidly for eighteen to twenty years, and under good conditions its maximum age for best effect is about thirty years.

MUGHO OR MOUNTAIN PINE *(Pinus Mugo)*.—This is the very attractive European Mountain Pine. The specimens commonly seen are shrub-like and globular in outline and are frequently used for foundation plantings because of their attractive appearance immediately upon being set out. This pine is recommended with the following reservation. Two seedlings in a single planting seldom grow at the same rate, and there may be considerable variation in size and height in a planting. The Mugho Pine tends to be rather short-lived (25 years), and as it reaches maturity it does get rather tall and somewhat bushy.

Mugho Pine *(Pinus Mugus)*
Fifteen-year-old trees near main gate at the Arboretum.

WESTERN YELLOW PINE OR BULL PINE *(Pinus ponderosa)*.—A native of western North America, this pine has long, heavy needles and a massive, loose type of growth. It is generally used for background plantings where a heavy texture is desired. It is fairly easy to transplant, drought-resistant, needs no particular attention, and can be planted in an unprotected location. One must be cautious, when purchasing this pine, that the nurseryman obtained his stock from geographic races adaptable to the St. Louis type of climate.

RED PINE *(Pinus resinosa)*.—This is a native northern pine very similar in appearance and growth habit to the Western Yellow Pine. It has masses of long, soft, deep green needles which form a striking contrast with the reddish bark. It is recommended for a specimen tree or for massive background plantings, and in a good locality in the city seems to grow even better than the Western Yellow Pine. The same caution should be observed in purchase of this pine as was mentioned for the Western Yellow Pine.

SCOTS PINE *(Pinus sylvestris)*.—In general, this pine cannot be recommended for St. Louis, although it is commonly offered by local nurserymen and is much planted by local gardeners. Even though it is a rapid grower, transplants easily, and has a fairly good shape when young, it soon becomes ragged in appearance with loose, thin foliage. It is also subject to attack by sapsuckers and is very short-lived.

SHORT-LEAF PINE *(Pinus echinata)*.—This is the native Missouri pine,

A group of young Mugho Pines, probably all planted at same time.

but it is very difficult to get established. Recent experiments at the Arboretum at Gray Summit have led to the conclusion that mycorrhizae are necessary in the roots before the plant can become established. Well-rotted manure may help to inoculate the roots with this important fungus, but this pine cannot be recommended until more is known regarding its cultural requirements.

JACK PINE *(Pinus Banksiana)*.—This is one of the northern short-needled scrub pines with open dense foliage. It is similar to the Short-leaf Pine in growth and appearance. It is too scrubby for a formal planting but can be used where a picturesque rugged effect is desired.

JUNIPERS

UPRIGHT JUNIPERS

ROCKY MOUNTAIN CEDAR *(Juniperus scopulorum)*.—This is a variable species native to the Rocky Mountains. Many beautiful blue and silver varieties and forms are offered by nurseries. In general, they will stand full exposure and the hot dry summers so common to St. Louis and can be highly recommended. They exhibit rapid growth and tend to become wide-spreading, hence should be planted in a place where they will have plenty of room to expand.

RED CEDAR *(Juniperus virginiana)*.—A native to Missouri, this is one of the most commonly planted cedars in St. Louis and perhaps the most reliable. Although there are numerous varieties and forms of this species, some do not thrive as well as others. In general, most of the varieties purchased from midwestern nurserymen will prove suitable for city and county planting.

Rocky Mountain Cedar
(Juniperus scopulorum horizontalis)

LARGE BUSHY JUNIPERS

VON EHRON JUNIPER *(Juniperus Sabina* "Von Ehron"*)*.—This imported European juniper is a very rapid and vigorous grower which is capable of making a magnificent plant if given plenty of room. It has no central trunk but the long, slanting branches give the plant a low-tree appearance. Another good characteristic is that it is resistant to the juniper blight. It should not be used for foundation plantings as it soon becomes too large.

SCHOTT'S JUNIPER *(Juniperus virginiana Schottii)*.—One of the many good varieties of *J. virginiana*, this bushy upright juniper has proved itself well adapted for the St. Louis climate. It stands full exposure and grows as rapidly as other varieties of *J. virginiana*. This is a heavy fruiting variety and retains its natural foliage color throughout the winter.

MEYER'S JUNIPER *(Juniperus squamata Meyeri)*.—Another of the Chinese junipers, this is one of the most picturesque upright varieties available for this area. It has a spiny, bluish foliage arranged in irregular bunches and takes on a plum-colored "blush" during the winter. The bush tends to become bare-branched at the base as it approaches maturity, and specimens are best used with lower-growing forms screening it in front.

PFITZER'S JUNIPER *(Juniperus chinensis Pfitzeriana)*.—This is probably one of the commonest evergreens found in St. Louis gardens and is also one of the most robust of the junipers. It grows very rapidly, forming a broad, irregular, low tree, with handsome dark-green foliage. It is so well known that it needs no further comment.

LOW SPREADING JUNIPERS

ANDORRA JUNIPER *(Juniperus communis depressa plumosa)*.—This and the following three junipers are all low-spreading, ground-cover types which are excellent for terraces and rockeries. All of these varieties are very hardy. The Andorra Juniper is bright green during the spring and summer, and becomes plum-colored during the winter.

A group of Junipers at the Arboretum showing the three main types: large bushy *(Juniperus chinensis Pfitzeriana)*, in foreground; columnar upright *(J. communis hibernica)*, and several tall upright *(J. virginiana)* in the background.

BAR HARBOR JUNIPER *(Juniperus horizontalis* "Bar Harbor"*)*.—This is perhaps the lowest of this group of junipers. It has steel blue foliage and does not change color during the winter.

WAUKEGAN JUNIPER *(Juniperus horizontalis Douglasii)*.—This is another selected prostrate form which becomes plum-colored in winter and does very well, particularly on rather sandy soils. It is intermediate between the very low "Bar Harbor" Juniper and the Japanese Juniper, the tallest of the group.

JAPANESE JUNIPER *(Juniperus chinensis japonica)*.—Although this is the tallest of the low forms, it seldom reaches a height of more than 24 inches. Its needles are rather sharp and bunched in small rosettes. This is perhaps the very best of this group of low junipers for St. Louis gardens.

Spruces and Firs

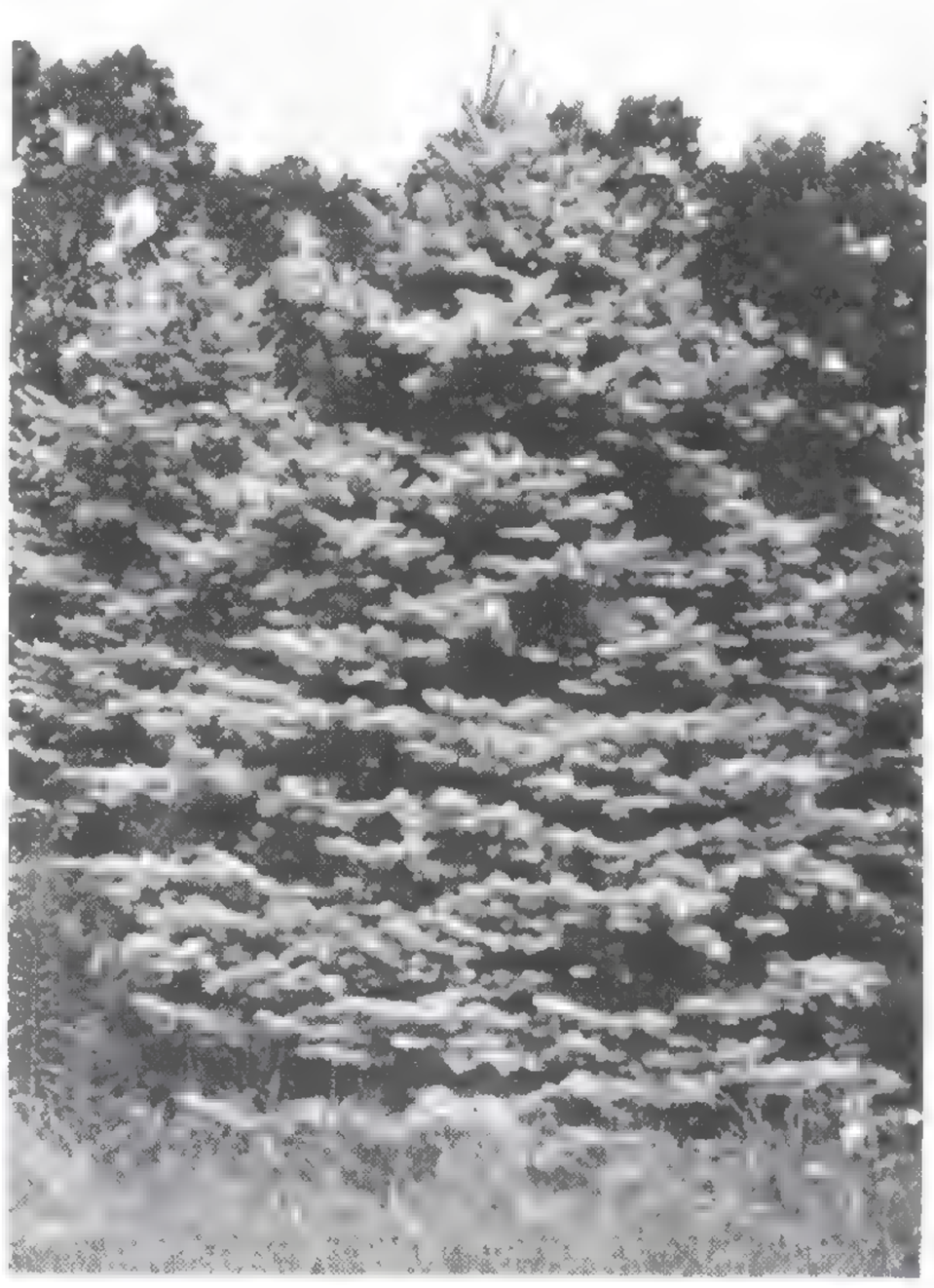
Every one is familiar with these evergreens which are commonly used as Christmas trees. They are characterized by their short needles, the regular arrangement of their dense branches, and their pyramidal shape. Most of the spruces and firs are native to the northern or northwestern states and generally do not survive the hot summers and dry winds so common to this part of the country. Although some of these are listed as being hardy and drought-resistant, they will make better growth and appearance if planted

Norway Spruce *(Picea Abies)*

in protected locations. All of those listed can be used effectively as specimen trees, for windbreak plantings, or as background groups.

Norway Spruce *(Picea Abies)*.—Among the spruces the Norway Spruce is one of the most commonly used in St. Louis gardens. Its dense dark green foliage and pyramidal shape make it an attractive tree. This is a very hardy and drought-resistant tree and a most rapid grower. In a good location and on well-fertilized soil, this fine conifer will live between twenty and forty years, although some do tend towards a scraggly appearance in old age.

Japanese Black Pine *(Pinus Thunbergii)*
Showing typical "tallow candle" growth at tips of branches.



Colorado Spruce *(Picea pungens)*
One of the most popular evergreens in the St. Louis area.

Tigertail Spruce *(Picea polita)*.—This is one of the Japanese spruces which has proved to be very well adapted to this climate. It has rigid spiny needles and conspicuous winter buds. Growing much slower than the Norway Spruce it is hardy, stands full exposure and heat, and does better on poor soil than some of the other spruces mentioned.

Northern White Spruce *(Picea glauca)*.—This is one of the larger species of spruce, reaching 60–70 feet at maturity. It has a broad, compact pyramidal form and short, thick, bluish-green needles. It stands the wet spring conditions better than the following variety and can be more highly recommended.

Black Hills Spruce *(Picea glauca densata)*.—Although this spruce is rather slow to become established, it eventually becomes a very striking tree with its dense horizontal branches and pyramidal shape. Because this tree does not like the wet spring conditions, specimens planted at the Arboretum have not proved as promising as was at first expected. However, if planted in a well-drained location it can be grown in this locality with reasonable success.

Serbian Spruce *(Picea Omorika)*.—In spite of its picturesque shape and general availability, this slow-growing spruce is extremely difficult to get established and is not recommended for St. Louis gardens.

Colorado Spruce *(Picea pungens)*.—The Colorado Spruce is probably the best spruce for this area, and the blue varieties are very popular with St. Louis gardeners. In planting these trees it should be kept in mind that they are rapid growers and become very large and so should be placed where plenty of room is available. Although most of the varieties of this spruce are characterized by a blue-white color, there are those which are much more nearly green.

Koyamai Spruce *(Picea Koyamai)*.—The Koyamai Spruce forms a very narrow pyramidal tree, reaching a height of 60 feet at maturity.

Oriental Spruce *(Picea orientalis)*.—This spruce forms a graceful, dignified tree with ascending or sometimes slightly spreading branches and slightly pendulous branchlets. It reaches 80 feet in height at maturity. This and the preceding oriental spruce are gradually becoming available in the nursery trade, and in general they can be recommended for the discriminating gardener.

Silver Fir or Colorado Fir *(Abies concolor)*.—This is by far the best of the firs for the St. Louis area. However, one must be careful to obtain varieties from the drier parts of its native range in Colorado and not from the Pacific Coast. The unusually long and wide-spaced needles sometimes give this fir almost the appearance of a pine. Its silvery foliage makes it an attractive lawn specimen.

Japanese Fir *(Abies firma)*.—This tree is a rapid grower, sometimes growing as much as 24 inches in a year, and it appears to do well in the Midwest. However, it should be given wind protection from the south and southwest whenever possible. It can be used to good advantage in a border planting or as an individual specimen.

Yews

Many forms and varieties of yews are available in the trade, all having either an upright or spreading growth habit. They should be protected from the sun during the hottest days of the summer and sheltered from severe winter winds, but with a little care the average gardener can obtain good results with these aristocrats of the plant world. The following varieties can be recommended for this area.

Taxus cuspidata capitata.—This is an upright form of the Japanese yew. It can be sheared to give a formal hedge effect and adapts itself to a variety of locations.

Taxus media Hatfieldii.—A cone-shaped form which can be sheared for formal hedges and is quite handsome as an individual specimen.

Taxus media Hatfieldii, one of the best yews.

Taxus media Hicksii #1.—A spreading type of yew which can be used for very good effect in foundation plantings.

Taxus media Hicksii #2.—A very narrow upright form lending itself to many formal and informal types of plantings.

Hemlocks

Canadian Hemlock *(Tsuga canadensis).*—A beautiful evergreen which can be used in background planting, as a lawn specimen, or as a hedge when sheared. To insure longer life these trees should be shielded from the hot, dry south and southwesterly winds; consequently they do better on a moist, northeast slope.

Carolina Hemlock *(Tsuga caroliniana).*—This evergreen does not do well in the Midwest.

Douglas Fir

Pseudotsuga taxifolia.—This species can be recommended for this area but should be obtained from a reliable nursery. It closely resembles spruce and fir

Colorado Fir *(Abies concolor)*
The best of the firs recommended for this area.

Douglas Fir *(Pseudotsuga taxifolia)*
22-year-old specimens at the Arboretum.

but in general it is a more rapid grower, a well-planted specimen growing about a foot in a year. It retains its lower branches even at maturity. However, being very shallow-rooted, older trees are occasionally tipped over by strong winds.

Larches

Larch *(Larix decidua)*.—As its name implies, this is a deciduous conifer which does very well here. It should be planted in a moist sheltered location, and will add a striking effect to the garden.

Golden Larch *(Pseudolarix Kaempferi)*.—This tree has the same characteristic growth habit as Larix, and can be used in the same manner. The main difference is that in the Golden Larch all the needles arise from short shoots.

Cypress

Bald Cypress *(Taxodium distichum)*.—This is another deciduous conifer which can be highly recommended for St. Louis. It is a rapid grower, stands the hot weather, and is unusually resistant to disease. Its tall, pyramidal shape and beautiful light green color in the spring make it a very

desirable specimen tree. It should be planted more frequently. (See May 1949 issue of the Garden BULLETIN for article on "Bald Cypress.")

ARBORVITAE

There are two kinds of Arborvitae commonly planted in this area: the native American *(Thuja occidentalis)*, and the Oriental *(Thuja orientalis)*. Although both are sold by most nurseries, they cannot be recommended for permanent effects in St. Louis. The native species burns in hot weather and should be planted in sheltered situations. The Oriental Arborvitae is attractive when young, but becomes increasingly ragged with age and may become positively objectionable.

This list of conifers by no means encompasses all those which may be grown here, but it does represent the kinds which have withstood the test of time in this climate.

NOTES

Mr. A. P. Beilmann, Manager of the Arboretum, has been appointed on the board of Conservation College (Iberia College), Iberia, Mo.

Mr. Hans Gubler, of Zurich, Switzerland, will spend the coming year at the Garden studying methods of breeding and growing orchids.

Among the visitors to the Garden during the summer were: Mr. Donald Wyman, of the Arnold Arboretum, Boston, Mass.; Mr. and Mrs. Percy C. Everett, of Rancho Santa Ana Botanic Garden, Anaheim, Calif.; Mrs. Dorothy S. Behrends, Editor *The Begonian*.

A tuber of the tropical pygmy water-lily, *Nymphaea sulfurea*, has recently been received at the Garden, having been sent by Mr. Robert Trickett, of Ealing, London, England. The tuber was collected in northern Rhodesia, Africa, and represents a species not before introduced into this country. If it can be successfully grown here it will be used in breeding new pygmy varieties.

The following botanists and other investigators made use of the Garden library and herbarium during the summer months: Dr. and Mrs. H. D. Herrington, of Colorado A. & M. College, Fort Collins, Colo.; Dr. Mildred Mathias, of the University of California, Los Angeles; Dr. R. W. Smith, of

the University of Missouri, Columbia; Mr. C. C. Deam, of Bluffton, Ind.; Dr. Charles B. Heiser, of the University of Indiana, Bloomington; Dr. Charles Rick, of California Agricultural Experiment Station, Davis; Dr. and Mrs. F. Marion Ownbey, of Washington State College, Pullman; Dr. Gerald B. Ownbey, of the University of Minnesota, Minneapolis; Dr. Hedda Nordenskiold, of the Botanical-Genetical Institution, Royal Agricultural College, Upsala, Sweden; Dr. H. S. Rappleye, of the University of Maryland, College Park; Dr. Julio O. Morales, of the Inter-American Institute of Agricultural Sciences, Turrialba, Costa Rica; Dr. John L. Heller, of the department of classics, University of Minnesota, Minneapolis; Dr. Volney Jones, of the University of Michigan, Ann Arbor; Dr. P. C. Joshi, of East Punjab University, Amritsar, India; Mr. Balaji Mundkur, of Southern Illinois University, Carbondale; Mr. R. W. Vaughk, of the Missouri Conservation Commission, Owensville, Gasconade Co.; Dr. George B. Llano, of the Smithsonian Institution, United States National Museum, Washington, D. C.; Dr. Lloyd H. Shinners, of Southern Methodist University, Dallas, Texas; Dr. William L. Brown, of Pioneer Hi-Bred Corn Co., Johnston, Iowa.

Dr. Gustav L. Mehlquist, Research Horticulturist to the Garden, attended the Centennial Symposium on Plant Nutrition and Plant Growth Substances, held at the University of Wisconsin, Madison, September 1–7.

Mr. Richard W. Holm and Mr. Hugh Iltis, graduate students at the Garden, returned in August from a two-months plant-collecting trip. Making their base at the Inter-American Institute of Agriculture, Turrialba, Costa Rica, they travelled throughout that country and brought back about 10,000 dried specimens and 40 living plants.

THE MISSOURI BOTANICAL GARDEN

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SOME FACTS ABOUT THE GARDEN

The Missouri Botanical Garden was opened to the public by Mr. Henry Shaw about 1860. From that date until his death in 1889 it was maintained under his personal direction. Although popularly known as "Shaw's Garden" the name Missouri Botanical Garden was chosen by Mr. Shaw and he definitely indicated that he wished it called by that name. The Garden passed at his death into the hands of a Board of Trustees, designated in Mr. Shaw's will, and the Board so constituted, exclusive of certain ex-officio members, is self-perpetuating. By a further provision of the will the immediate direction of the Garden is vested in a Director, appointed by the Board. The Garden receives no support from city or state but is maintained almost exclusively from the estate left by Henry Shaw. Since 1939 many Garden Clubs and interested individuals have contributed to a "Friends of the Garden Fund" which is used in developing the new Arboretum, located at Gray Summit, Mo. The Arboretum (1) serves as a source of plants, trees and shrubs for the city Garden; (2) affords areas for gradually establishing a pinetum, a wild-flower reservation and various other features on a scale not possible in the city; (3) provides greenhouses for some 20,000 orchid plants.

The city Garden comprises 75 acres, where about 12,000 species of plants are grown, both out of doors and under glass. It is open every day in the year except New Year's Day and Christmas; week days, 8:00 a. m. until 7:00 p. m.; Sundays, 10:00 a. m. until 7:00 p. m. The greenhouses are closed every day at 5:00 p. m.

The main entrance to the Garden is at Tower Grove and Flora Place, on the Sarah bus line (No. 42). The Tower Grove bus (No. 21), direct from downtown, passes within three blocks of the main entrance.

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Missouri Botanical Garden Bulletin

Vol. XXXVII OCTOBER, 1949 No. 8

THE ROLE OF THE KOREAN HYBRIDS IN THE DEVELOPMENT OF THE NEW HARDY GARDEN CHRYSANTHEMUMS

J. RICHARD KUYKENDALL AND DAVID O. GALEY

Perhaps no other flower than the hardy garden chrysanthemum can give the last glorious splurge of color in the home garden. The beautiful new varieties of hardy mums can be made to blend most effectively with the coloration of the autumn foliage. Each year the nursery catalogues list increasing numbers of new and desirable varieties which leave the flower-lover with many breath-taking memories as he retreats from his garden with the coming of winter.

The tremendous interest recently exhibited in the hardy garden chrysanthemums is the result of extensive breeding by mum fanciers and commercial growers during the last twenty years. When it is realized that the culture of chrysanthemums probably antedates the Christian era by nearly a thousand years, the development of the present-day hardy mums seems to fill a very small niche in the over-all history of the plant. Emsweller, in an article on the history of the chrysanthemums[1], points out that the Chinese were growing improved varieties as early as 500 B. C., and that they were introduced to Japan by 749 A. D. At first they were grown only in the imperial gardens but soon became popular not only with the nobility but with the masses. During all these years the chrysanthemums were grown as garden plants, and it wasn't until 1850 that a few varieties of these early "garden" mums were tried under glass. From this time until the early 1930's most of the emphasis in growing mums was centered on the development of florist types and their commercialization as a florist crop.

In speaking of the development of garden varieties of mums, if one may use terms of history, the period between 1850 and the late 1920's would seem to be the "dark ages." In 1929 an event took place at Bristol Nurseries,

[1]Emsweller, S. L. The Chrysanthemum: Its Story through the Ages. Jour. N. Y. Bot. Gard. 48:26–29. February, 1947.

Bristol, Conn., under the direction of Mr. Alex Cumming, which can be considered the decisive one in bringing garden mums out of the obscurity of their "dark age." This event was the crossing between a garden variety, RUTH HATTON, one of the best mums belonging to the garden species *Chrysanthemum hortorum*, and the distinct and hardy species, *C. coreanum*. From the seedlings of this particular cross, Cumming developed a new line of garden mums which he called "Korean Hybrids." These hybrids created, almost over night, a new interest in breeding and development of hardy garden varieties.

The reader may well wonder what is meant by the term "hardy chrysanthemum," or "hardy mums." To the plant breeder it means an extremely varied group of chrysanthemums, now including many hybrids which are the result of crossing such species as *Chrysanthemum coreanum*, *C. arcticum* and *C. nipponicum* with the older horticultural varieties of *C. hortorum*. To the home gardener, "hardy mums" are those varieties which are sufficiently hardy to be grown out of doors and which mature their flowers before frosts kill the plants.

It is generally believed that the modern chrysanthemums have been derived primarily from two oriental species, *Chrysanthemum morifolium* and *C. indicum*, both native to China. Although there is still much speculation on the subject and no concrete evidence to support the idea, it is generally considered that the large-flowered, florist types were derived from *C. morifolium*, and the smaller-flowered, garden types from *C. indicum*.

The species *C. indicum* is vine-like, with small, single, and pure yellow flowers approximately a half inch in diameter. In some parts of the country it it reported to bloom in the greenhouse late in September, but in St. Louis it does not bloom until after November 10. *C. morifolium* appears to have been originally a stiff upright plant, with single flowers ranging in color from white to pink. The species as it is known today has rosy lilac flowers with lavender shading.

Japanese flower-growers have played a very important role in the development of chrysanthemums, and the history of the plant in Japan is a long one. However, there seems to be some confusion in various reports as to the actual date of the introduction of chrysanthemums in Japan and some question as to the locality from which they were introduced. Emsweller, in the article previously mentioned, states that mums were introduced to Japan from China about 724 to 749 A. D. On the other hand, according to Cumming, ". . . It is a matter of record that in A. D. 386 seed of the chrysanthemum was introduced to Japan from a foreign country. That foreign country, Taik-tse, is

now one of the states of Korea . . . ."[2] In 910 A. D., under the rule of Emperor Uda, the chrysanthemum was adopted as the national flower of Japan. About this period the first double forms of *Chrysanthemum morifolium* appeared, and there are indications that the modern garden double types are descended from this first double form. Cumming also points out that the color range in these very early garden mums included blue, red, yellow, white, and violet. There is no accounting for the blue color mentioned in the records, since there is no color which can be considered a real blue in any of the present-day species or hybrids of Chrysanthemum.

On account of the many references in the literature to the garden species *C. hortorum*, it should be pointed out that it is neither a described species nor a type, but refers to any cultivated variety of mum derived from interbreeding the species *C. indicum* and *C. morifolium*. In this article, *C. hortorum* or hortorum types of mums will refer to any of the large group of older garden mums other than Korean hybrids.

In older hortorum varieties there is considerable range in color, growth habit, and hardiness. Some of the general characteristics of these "Pre-Korean" mums were added to the garden varieties which were in commercial use prior to Cumming's breeding of *C. coreanum*. These are listed below with the names of the commercial varieties which typify the particular characteristic.

Color Range: White—RUTH HATTON; Pink to Lavender—OCTOBER GIRL; Pure yellow—MARION HATTON; Bronze—GRANNY SCOVILLE; Crimson—GRENADIER.

Hardiness: Slightly hardy—NORMANDIE; Very hardy—AUTUMN GLOW.

Earliness: AMELIA, BARBARA CUMMING.

Lateness: CAPT. R. H. COOK, JANE SAUNDERS.

It is obvious that within the hortorum group there are some excellent characteristics of color, hardiness, and fairly definite blooming dates, although few of these varieties have an extensive blooming period. Practically no varieties combine all of these desirable characteristics in the same plant. One of the foremost breeders of these older hortorum types was Prof. F. L. Mulford, associate horticulturist of the U. S. Department of Agriculture. He is noted for his work in developing varieties which were resistant to both the heat of late summer and cold of early winter. Perhaps his two best-known introductions are ALGONQUIN, an early, very double, yellow mum, and GERONIMO, an early double, light-bronze variety.

Toward the end of the 1920's improvement in garden chrysanthemums seemed to be nearly at a standstill, and further development appeared to be

[2]Cumming, Alex. Hardy Chrysanthemums. New York, 1945.

Chrysanthemum Show in the Floral Display House at the Garden
(Photograph by Claud Johnson)

limited to combining all the desirable features which were on hand in the garden mums. Alex. Cumming says:[3] ". . . . Between the years 1928 and 1933 some sixteen varieties of the pre-Korean or hortorum type had been developed and introduced from Bristol. All of these I considered improvements in some particular respect. The aim was towards increased hardiness

[3]Hybrid Korean Chrysanthemums—Their History. Plants and Gardens 1:165–166. Brooklyn Botanic Garden. Autumn, 1945.

and a better growing plant, but the process was tedious and no definite advance was accomplished."

In 1928, Mr. Cumming realized that it would either be a question of seemingly fruitless interbreeding of the older hortorum types in an effort to achieve the right combination, or the introduction of some outside blood. To quote Cumming again: ". . . . It appeared that the answer would be in new and more virile blood, which meant the introduction of some entirely distinct but related species . . . ." The discovery of the "new blood" was the result of some keen observations made by Mr. Cumming of a number of hardy species native to the northern Orient. It was his good fortune to choose the Korean Daisy *(Chrysanthemum coreanum)* with which to start his breeding experiments, a plant with the needed traits of extreme hardiness and vigorous growth, and having single flowers about two inches across, pure white when first open, pink with occasional carmine-pink tones when mature. The species was a native to Korea and lower Siberia. It was brought to America in the early 1900's by Mr. J. G. Jack, although the credit for the introduction is generally given to E. H. Wilson of the Arnold Arboretum, and was later introduced to the American gardens by Harlan P. Kelsey. Even though plants of the species *C. coreanum* were thus available in the commercial nursery trade, the species remained in obscurity until October 1928 when Mr. Cumming started breeding it into the older hortorum varieties and produced the now famous Korean hybrids.

To illustrate the types of new garden mums which resulted from breeding in *C. coreanum* Mr. Cumming's account in *Plants and Gardens* of one of his original crosses is herewith quoted: ". . . . In the autumn of 1929[4] many crosses were made in which *C. coreanum* was used as the mother parent; in others as the pollen or male parent. From among these an original cross between RUTH HATTON and *C. coreanum* produced some thirty seedlings in that year. One of these proved of particular value. Our records described it as 'white to light pink. Grow 25 for observation, and self (meaning inbreed), this might be a hybrid.' This it later proved to be. It was numbered 64-29, doubtless the first actual Korean Hybrid of record." The substance and gloss in the flowers of the plants resulting from this first cross positively indicated the Korean parent, showing that it was possible to make an inter-specific cross between the older hortorum types and the species *C. coreanum*. Nearly all the Korean hybrids now in the trade are the result of further breeding from this original cross.

One of the original "*C. coreanum* × RUTH HATTON" crosses, in which *C. coreanum* was used as the female parent, produced a single light yellow-

[4] This may be a typographical error in Cumming's 1945 article, because in his book (Hardy Chrysanthemums, Doubleday & Co., 1945) he states that the first cross was made in October 1928, and the first actual Korean hybrids flowered in the fall of 1929.

MERCURY

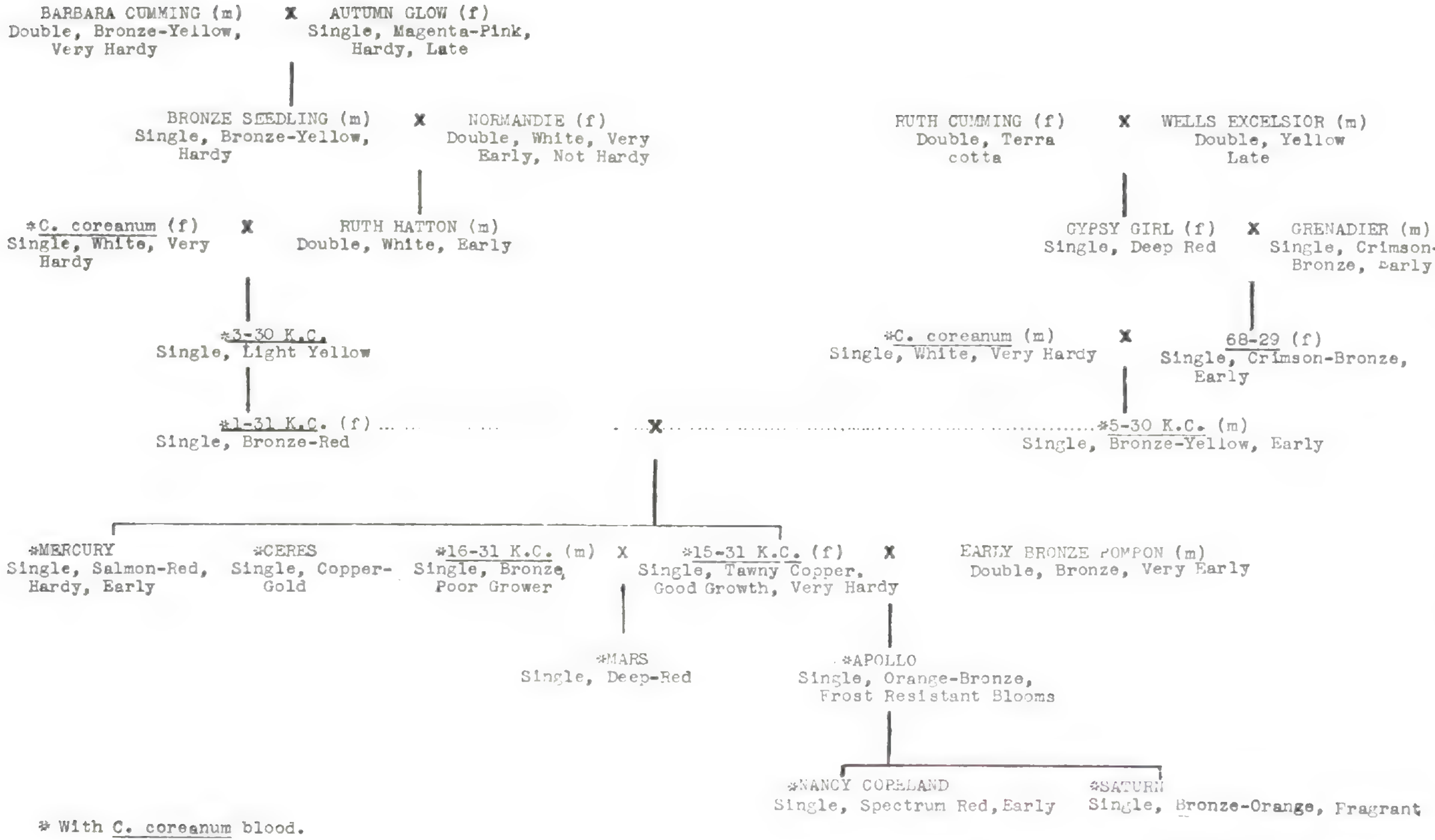
flowered mum (3-30 K.C.). From this single yellow was developed a single bronze-red flower (1-31 K.C.). This bronze-red in turn was crossed to another Korean hybrid (resulting from crossing *C. coreanum* to a descendant of GYPSY GIRL and GRENADIER), and from this were developed a number of the first Korean hybrids to be placed in the trade in 1933 and 1934. One of the most outstanding of these first introductions was a variety called MERCURY, described in the 1933 Bristol Nurseries catalogue as follows: "The flowers are rich ox-blood red suffused with coppery bronze, contrasting vividly with a golden yellow disc in the center. . . . In contrast with the pungent odor typical of most Chrysanthemums, 'Mercury' has a delightfully sweet fragrance. . . ." Plants of MERCURY were more robust, had a more branching habit, more attractive and effective growth, and a hardiness surpassing any previous garden type of mum. Another early introduction of Cumming's was the variety APOLLO, the first of the bronze single varieties. The flowers of CERES were a blend of old gold, chamois-yellow, and soft coppery bronze, and they showed remarkable keeping quality when cut.

The first of the double Korean hybrids were quite as distinctive as the new single varieties, differing from the older double hortorum varieties chiefly in their added hardiness and more brilliant coloring. Nearly all the doubles descended from another of the original Cumming crosses in which RUTH HATTON was the female parent and *C. coreanum* the male parent. The more tender hortorum varieties BARBARA CUMMING, GRANNY SCOVILLE, and ALADDIN were used to bring in the factor for earliness. There was, of course, considerable selection involved to retain the desired quality of hardiness. The

BARBARA CUMMING

variety THE MOOR is neither very hardy nor robust, but has an outstanding amaranth or wine color. EMBER is considered super-hardy for mums, and has orange and coral shades in its bronze-colored flowers with the added feature of frost-resistant blooms.

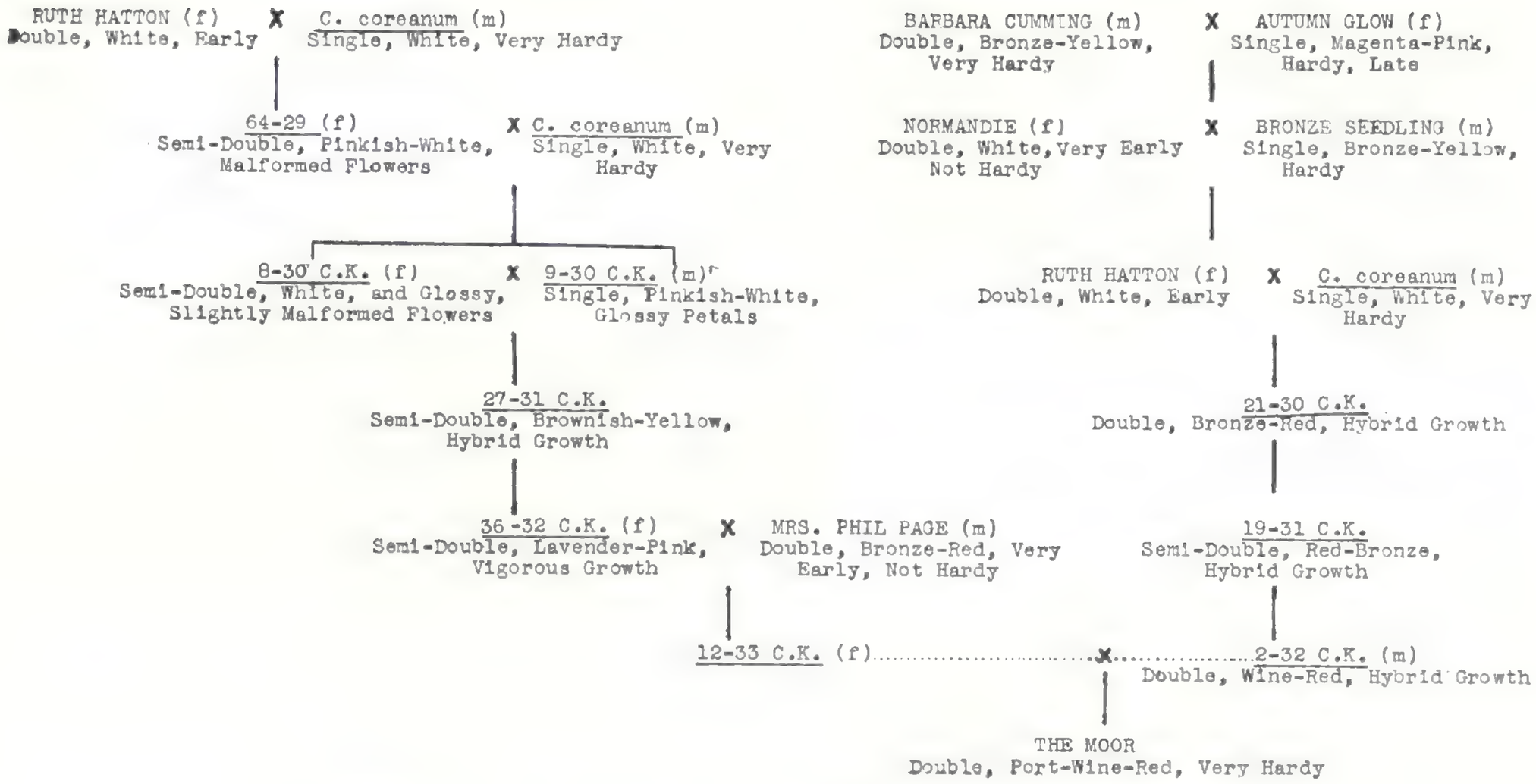
For the sake of plant breeders and those interested in tracing the origin of some of the characteristics which appeared in the first Korean hybrids, charts tracing the lineage of some of the varieties mentioned above are given on pages 168–169. Any one familiar with color inheritance in chrysanthemums might question the fact that a single light yellow flower resulted from crossing the single and white *C. coreanum* with the double and also white RUTH HATTON. The charts will help to clarify this matter by showing that RUTH HATTON was carrying genes for yellow flower color, probably inherited from the variety BARBARA CUMMING. From further study of the flower colors which appeared in subsequent offspring of this same cross, the possibility is indicated that *C. coreanum* was carrying a gene for anthocyanin (red color) production which was not present in RUTH HATTON. In other words, RUTH HATTON may have carried the factor for red color, but this color would not become apparent until in combination with the anthocyanin-producing factor. The introduction of this color-production factor from *C. coreanum* probably was responsible for the appearance of the bronze and deep red in some of the later Korean hybrids.



* With C. coreanum blood.

Modified from Cumming

SINGLE KOREAN HYBRIDS OF CHRYSANTHEMUMS



DEVELOPMENT OF DOUBLE KOREAN HYBRIDS OF CHRYSANTHEMUMS

CERES

In general, then, some of the characteristics which were added to garden chrysanthemums by the breeding in of the "new blood" of *C. coreanum* were the following: intensification of flower color and added lustre and brilliance; increased hardiness; longer periods of bloom; increased range and variety of flower color; a greatly increased tendency to have large masses of flowers in bloom at the same time, due to the typical Korean hybrid trait of branching from the ground; and in some more recent varieties a pleasant fragrance differing from the rather harsh strong scent of the older hortorum varieties.

The genetic changes involved in the formation of the Korean hybrids may be explained as follows: It was found that when *C. coreanum* was selfed, it bred true to type from seed; that is, nearly all the offspring were like the parent or homozygous. Cumming claims that when RUTH HATTON was selfed it segregated into plants having flower colors of the older hortorum types[5]. When these two plants were crossed, the color shades of the hortorum types were maintained but with a new intensity, an added lustre, and greater glossiness. In some of the new varieties there appeared a luminescent sheen which was not evident in the hortorum types. Cumming, in his book on "Hardy Chrysanthemums," gives Mrs. A. J. Vanderpoel's explanation of this

[5] The flower colors predominant in the older hortorum types were white, pink, yellow, and lavender.

luminescent sheen, which was, "that no new color factor has been added but that the petal surface of *coreanum*, which is starch-like and glossy, elaborates existing colors through greater reflection, just as the surface of a color film screen may affect the reproduced picture." The writers feel that Mrs. Vanderpoel's idea was generally correct, but that, more specifically, the new effect was due to intensifying color genes carried by *C. coreanum*. In addition to the genes for color intensification, *C. coreanum* also had genes which provided for more hardiness and robust growth.

After Cumming showed that it was possible to make inter-specific crosses between closely related species of the genus Chrysanthemum, other mum-growers, as well as Cumming, started rather extensive breeding programs using such species as *C. arcticum*, *C. nipponicum*, *C. coccineum*, and *C. rubellum*.

The desirable characteristic of remarkable hardiness has made *Chrysanthemum arcticum* a valuable tool in the mum-breeders hands. The species is found in the Arctic regions of Europe, Asia, and America. Plants are of a low tufted habit, seldom more than fifteen inches tall, with single flowers about an inch and a half in diameter, pure white at first changing to light and sometimes dark pink when mature.

Chrysanthemum coccineum (Pyrethrum or Painted Daisy) is reported to have been used recently in mum breeding. Cumming claims, by using this species as the pollen parent, to have produced some hybrids between it and some of his Korean hybrids which show the infusion of some very desirable color shades, particularly reds. *C. coccineum* is a native to Persia and the Near East and is strictly a summer-blooming or long-day plant, while the hardy garden mums and Korean hybrids are fall-blooming or short-day plants. All the supposed hybrids in which *C. coccineum* was used as the pollen parent are fall-blooming or short-day plants, which tends to indicate that in these particular cases parthenogenisis had taken place and no actual hybrids were produced.

Chrysanthemum nipponicum, as its name implies, is a native of Japan. This species is different from all the other chrysanthemums discussed in being distinctly shrub-like with woody stems which produce new lateral growth each spring. The leaves are thick and leathery, and the flowers are large, about three inches across, with very thick pure white petals.

One of the breeders of hardy garden mums, Mr. Vincent De Petris, of Detroit, Michigan, has been known in the trade for many years for his production of many of the leading florists varieties, but more recently he has pioneered the development of the currently popular arcticum varieties. De-Petris has used *C. arcticum* to good advantage to bring into the garden mums

ALADDIN

PYRETHRUM OR PAINTED DAISY *(Chrysanthemum coccineum)*

the characters of rugged growth and extreme hardiness. He has also infused into his varieties the blood of *C. nipponicum* for soft pastel colors, the older hortorum types for double flowers, and *C. coreanum* for bold autumn colors. DePetris has this to say about his own work with the arcticum hybrids:[6] ". . . . The first acceptable results of the arcticum hybrids came in the varieties named ARCTIC QUEEN and CORAL SEA. The former resulted from crosses which, among others, included seedlings from VALENCIA, one of my best greenhouse single duplex varieties, and a Korean hybrid . . . ." ARCTIC QUEEN, with a semi-double bronze-red flower, is very hardy and possesses the typical low tufted growth and foliage of *C. arcticum*. CORAL SEA, which has copper-tinted salmon flowers, is one of the cushion type of mums.

ASTRID, an arcticum hybrid

Credit for the first arcticum hybrid, ASTRID, goes to Mr. and Mrs. J. Franklin Syter of Concordsville, Pennsylvania. Further productions from Syter's use of ASTRID have included the popular line known as "Northland Daisies." The flowers resemble rather closely those of typical Korean hybrids in color, but the petals are generally longer. The foliage and general growth pattern are typical of the arcticum hybrids, and the plants are extremely hardy.

Another leader in the field of developing new garden mums is Prof. Ezra J. Kraus, formerly dean of Botany at the University of Chicago. Dr. Kraus's

[6]De Petris, V. R. Chrysanthemum Arcticum Hybrids. Plants and Gardens 1:168–170. Brooklyn Botanic Garden. Autumn 1945.

hardy mums have been introduced into the trade as the "Chicago Strain." The original stock from which these mums were developed was primarily hortorum varieties developed by Prof. Mulford, of the U. S. Department of Agriculture, and some of Cumming's Korean hybrids. Kraus, writing about his mum-breeding work[7], mentions the following varieties which he has used as parent stock: the yellow variety ALGONQUIN (Mulford), for its relatively early and profuse blooming habit and its ability to withstand the winters in the Chicago area; GERONIMO, a bronze, and SEMINOLE, a white (both developments of Mulford), because they were early and winter hardy. With regard to other parent stock, Kraus writes: ". . . . Extensive use has been made of many of the varieties selected and introduced by Mr. Alex Cumming. . . . The list used is far too long to mention them all individually, but the very interesting color and sheen of GRANNY SCOVILLE, and the color, plant habit, and comparative hardiness of AUTUMN LIGHTS (one of Cumming's recent developments having *C. arcticum* in its lineage) deserve special mention. . . ." Among the most recent successful introductions by Kraus is the variety MEDITATION, which has large two-toned flowers, the upper petal surface being a bright orange-red and the reverse side pure orange. Another interesting Kraus hybrid is OLIVE LONGLAND, with its large apricot-tinted salmon-pink flowers.

Mention should be made of some of the more recent breeding work begun by the late Alex. Cumming and now being carried on by his son. Continuing his work with the Korean hybrids, Cumming introduced the blood of the species *C. arcticum* from which the variety AUTUMN LIGHTS, a brilliant bright red-orange single-flowered mum was developed. The very luminous petal character and heavy leaf texture of *C. nipponicum* have been imparted to two more outstanding Cumming varieties, MILKY WAY, a milk-white semi-double mum, and BURMA, considered by some to have the most perfect flower of any mum, with its copper and pink-tinted bronze flowers.

Among other breeders who are adding valuable new varieties to the ever-increasing list of garden mums is H. Roy Mosnat of Belle Plaine, Iowa. He has used some of the newer Korean hybrids in producing his well-known DEAN KAY strain, a rose-pink variety and perhaps one of the best of the larger cushion-type mums in the trade. Some interesting and promising early-blooming and frost-resistant varieties such as the pink cushion CODY and the copper-colored semi-double cushion OMAHA are being developed at the University of Nebraska. Early in June of this year the senior author had the opportunity to observe some of the mum-breeding work being done by Prof. L. E. Longley, assistant professor of horticulture at the University of Minnesota. Dr. Longley's primary aim during the last few years has been to develop

[7] Developing New Clones of Chrysanthemums. Nat. Hort. Mag. **24**:100–108. April, 1944.

mums which will bloom early enough to give a desired display of flowers before the killing frosts, sometimes occurring as early as the middle of September in the Twin Cities area. Some very satisfactory early-blooming plants have been produced, and the emphasis now is being placed on hardiness. " . . . The first Minnesota variety was introduced in 1939 under the name DULUTH. This is a tall, upright mum with semi-double, lemon-yellow flowers about 2 inches in diameter. It blooms early, profusely and for a long period. It is the hardiest Minnesota variety. . . ."[8] Among the named varieties being used by Dr. Longley for his breeding work are: De Petris' arcticum hybrid ALLEGRO, Kraus's Korean hybrid HEATHER BLOOM, and Mosnat's variety DEAN KAY. Perhaps the most popular of the Longley developments now available are the varieties CHIPPEWA and MAROON 'N' GOLD. CHIPPEWA forms a bushy plant sometimes 20 inches tall, with large clusters of rich purple, incurved flowers. MAROON 'N' GOLD is low-growing and very floriferous, the flowers being the largest of any of Longley's productions, with the upper surface of the petals a bright maroon and the under surfaces golden orange.

Today the hardy garden chrysanthemums hold a leading place in the autumn gardens of America. From early in September until the hard killing frosts of late autumn, when other flowers have disappeared from the garden, these plants provide a rich and varied assortment of color. All the recent breeding work and development of hardy mums have made use of plants infused with the blood of the Korean Daisy. Much of the credit for the rescue of the garden mums from their seeming "dark ages" and for making American home gardeners chrysanthemum-conscious must go to Mr. Alex. Cumming and his successful development of the now famous Korean hybrids.

To acquaint Garden visitors with hardy garden mums, a list has been prepared of most of the varieties which are on display in the Linnean Garden during the month of October. The names are listed alphabetically, and the plot where the plants can be found is indicated on the plan (page 176).

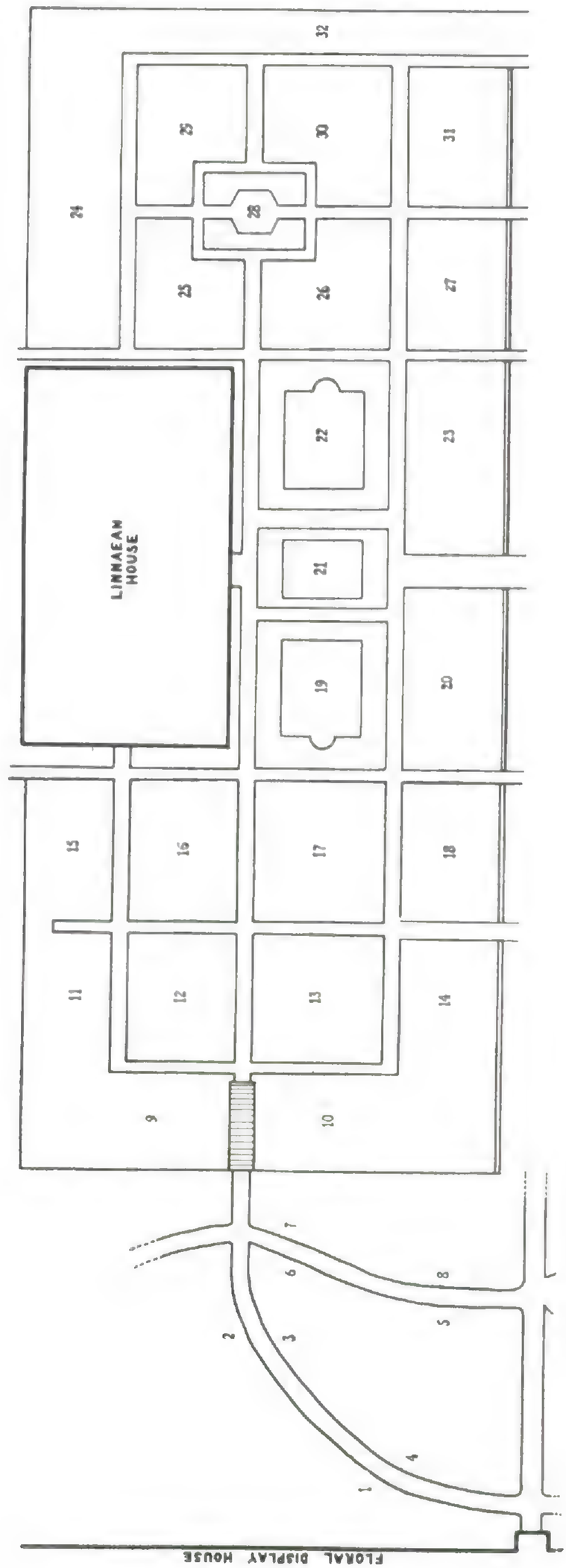
AGNES SELKIRK CLARK—One of the single Korean hybrids introduced by Bristol Nurseries in 1937. Flower color a blending of bronzy pink, apricot, and salmon. Plants rugged, yet compact and graceful, and remarkably free-flowering. Plots 23, 28.

AMELIA—Offered by a number of nurseries under several names including PINK CUSHION and AZALEAMUM. Plant dwarf, compact, cushion-like, with lavender-pink flowers. Can be used effectively for color mass. Plots 3, 27.

APRICOT GLOW—One of the fine cushion mums introduced in 1945. Masses of apricot-bronze flowers cover the entire plant. Plot 11.

ARCTURUS—A Korean hybrid introduced by Henry A. Dreer, of Philadelphia, in 1938. The single, amber or honey-yellow flowers freely produced after mid-October. Plot 11.

[8] Bjornson, Jo. Mums for Northern Climates. Flower Grower **34**:779, 790–791. Oct. 1947.



Map of Linnean Garden, showing location of chrysanthemum varieties described on pages 175, 177–178.

AUTUMN LIGHTS—One of the first single type arcticum hybrids developed by Cumming and introduced in 1940. Flower a coppery bronze. Plants compact, free-flowering, and perfectly hardy. Plot 3.

AVALANCHE—One of the many lovely Korean hybrids. Flowers large and perfectly formed, opening pure white and changing slowly to soft creamy shades. Plot 27.

BARBARA CUMMING—One of Alex. Cumming's pre-Korean hardy mums used in developing the first Korean hybrids. Flowers large, full, clear yellow shading to orange-bronze at the center. Particularly valuable for the long flowering period. Plot 3.

BARBARA SMALL—One of the "Chicago strain" of hardy mums developed by Dr. Kraus. Flowers a clear lilac-pink, with a carmine center. Plot 2.

BARNEGAT—One of the numerous fine hardy mums developed by Prof. Mulford. A very double, yellow mum blooming in mid-season and growing 18 inches high. Plot 25.

BOKHARA—One of the recent introductions of Bristol Nurseries. Flowers have an irridescent or luminous quality, the color being a blend of soft rosy crimson and wine shades. Plants very hardy and upright, with lusty, disease-resistant foliage. Plot 20.

BURGUNDY—Rich cerise-crimson, or ". . . the deep, rich red of fine old wine . . ." describes the flowers of this lovely double, sweet-scented mum. Blooms in clusters on heavy stems. Plot 29.

BURMA—A variety resulting from a cross between the little-known *C. nipponicum* and the Korean hybrid strain. Introduced in 1944. Flowers beautifully modelled and of a glistening bronze color with under-tones of copper and soft pink. Plot 11.

CERES—Another of Cumming's early Korean hybrids. The nicely formed single flowers, a combination of old-gold, chamois-yellow, and soft coppery bronze, are borne on sturdy plants. Plot 2.

CHARLES NYE—By far one of the finest pompons developed by Dr. Kraus. Flowers very large, deep yellow, produced freely in compact clusters. Plot 1.

COURAGEOUS—Another of Dr. Kraus's introductions. Good-sized, double, frost-resistant flowers carry the vivid, crimson-red color to the season's end. Plot 2.

DEAN KAY—This forerunner of H. Roy Mosnat's popular line of hardy mums has large, deep pink, semi-double flowers. Among the hardiest of the cushion type. Plots 2, 20 and 24.

EUGENE A. WANDER—Development of Mr. Cumming. One of the largest of early-blooming double varieties, with many huge, golden, perfectly formed flowers. A favorite for cut flowers. Plot 2.

FRED F. ROCKWELL—One of Bristol Nurseries' best new varieties. Very hardy, with frost-resistant blooms showing a rich brilliance in the blending of bronze and orange-scarlet tones. Plot 1.

FIREGLOW—Very hardy and early flowering. Flower color oriental red changing to a bronze-red. Plots 23 and 27.

HARBINGER—Another of Dr. Kraus's introductions with early-blooming, double, bronze flowers which are very good for cutting. Plot 2.

HARBOR LIGHTS—Introduced in 1944. Soft luminous yellow of flowers a blend of creamy white and primrose-yellow. Plot 15.

HEATHERBLOOM—An early-blooming, hardy mum, with very double heather-pink flowers. Plots 3 and 24.

HEBE—One of Bristol Nurseries' early Korean hybrids that has proved very hardy. Flowers a silvery pink and very fragrant. Plot 4.

IRENE—An all-double pompon, with neat, pure white blossoms. Plot 4.

KOREAN PRINCESS—Originated by Louis A. Reichert, from some of Alex Cumming's Korean hybrids, this is the first anemone-flowered Korean hybrid introduced. Flowers a bronze-red on opening, with a perfectly formed, golden-bronze cushioned center, changing to a strawberry crimson as they mature. Plants extra hardy and early-blooming. Plot 30.

LAVENDER LADY—A true aristocrat of the autumn garden is this full double, pure lavender-flowered mum. Excellent for cut flowers. Plot 30.

LAVENDER LASSIE—Similar to LAVENDER LADY, but with smaller flowers. Plot 15.

MAGNOLIA—Flowers a lovely blend of soft pink and creamy yellow. Plot 16.

MAJOR CUSHION—One of the best pink cushion type mums, with full petalled flowers on symmetrical free-flowering plants. Plots 4 and 24.

MME. CHIANG KAI-SHEK—An outstanding creation of Wayside Gardens. Flowers early-flowering, fully double, yellow-bronze. Plot 25.

MANDALAY—Popular Korean hybrid, with brilliant orange-bronze flowers. Excellent for cut flowers. Plot 27.

MRS. PIERRE S. DuPONT, III—The full double blooms are a lovely blending of rosy salmon-bronze and peach-pink. Plot 29.

NIOBE—A Korean hybrid introduced in 1936 by Henry A. Dreer. A very fine dwarf, compact plant. Flowers a clear, glistening white with yellow discs. Plot 4.

PRIMULA—A graceful plant with a profusion of single, yellow flowers. Plot 16.

RED HUSSAR—Introduced by Dreer, the duplex flowers of this variety are bright scarlet. The most brilliant late-flowering mum. Plot 3.

RED VELVET—This variety has added a new rich velvet crimson to garden mums. Plants very hardy and the blooms long-lasting. Plots 25 and 26.

R. MARION HATTON—One of Alex. Cumming's early hardy mums used to produce the Korean hybrids. Plants quite hardy, and the flowers a canary-yellow. Plot 30.

REMBRANDT—A 1943 introduction of the Bristol Nursery having fine double rose-mauve flowers with faint copper tints. Plot 3.

REVELLER—One of the best of the large English chrysanthemums which need a long season for full development. Flowers semi-double, a bright chestnut-red, at their best in late October. Plot 3.

ROSE GLOW—Husky, 2-foot plants, with early-blooming raspberry-pink flowers. Plot 1.

SEPTEMBER BRONZE—Among the earliest of the cushion mums. Flowers a small pompon, golden-bronze, with frost-resistant petals. Plots 1 and 25.

SEPTEMBER QUEEN—One of the fine double, white chrysanthemums introduced in 1930 by Elmer D. Smith of Adrian, Michigan, the dean of American chrysanthemum-breeders. Plot 12.

SILVER MOON—A good single, white Korean hybrid chrysanthemum. Plot 13.

SUMMERTIME—Flowers single, about 2 inches across, bright lemon-yellow, noticeably fragrant and carried on densely branching sprays. Plot 4.

SUPREME YELLOW—Another good early-blooming Azalea-like cushion mum. Flowers a soft shade of yellow. Plot 26.

TASIVA—Introduced in 1928 by Elmer D. Smith. A free-flowering, double, white mum unsurpassed by any present-day white varieties. Plot 26.

WHITE WONDER—The ball-shaped pompon blossoms with broad petals a soft creamy white at first, opening to a crisp, mellow white. Plot 25.

YELLOW SPOON—A unique, clear yellow, spoon chrysanthemum. Plot 17.

WHY DO CHRYSANTHEMUMS BLOOM IN THE AUTUMN?

GUSTAV A. L. MEHLQUIST

For centuries the garden chrysanthemum has been regarded as an autumn-blooming plant, yet today the florists are offering well-grown cut flowers of chrysanthemum almost the year round. This apparent contradiction can be explained very readily now but it was not so easy a puzzle to unravel.

In the early 1920's W. W. Garner and H. A. Allard, plant physiologists with the U. S. Department of Agriculture, undertook a series of experiments to ascertain what effect variation in day length might have on flowering

plants. It had been suspected by plant physiologists and horticulturists for some time that day length and temperature might be determining factors in the flowering habits of plants that showed distinct seasonal tendencies in this regard. However, no experiments had been conclusive until Garner and Allard's, the outcome of which was to cause a revolution horticulturally speaking. From these experiments in which they reduced or increased the length of time that the plants were exposed to light, Garner and Allard concluded that there were three kinds of flowering plants; namely, short-day, long-day, and indeterminate. The short-day plants were those that flowered after being exposed to relatively short days (11 hours or less) and long-day plants were those that required 14 hours or more of light. The plants that were found to flower regardless of the length of day were called indeterminate. Typical short-day plants are chrysanthemum, gardenia, Christmas begonia, and poinsettia. Typical long-day plants are the China aster, calceolaria (fig. 1), and many common spring annuals. The indeterminate group is typified by our modern roses and carnations. It should be borne in mind, however, that not all members of a genus necessarily fall in the same groups. For instance, in the genus Chrysanthemum we find that the common garden chrysanthemum, *C. hortorum (morifolium)* (fig. 2) is the outstanding example of a short-day plant, but its relatives *C. carinatum* and *C. coronarium* (the annual chrysanthemums), *C. Parthenium* (the feverfew) and *C. coccineum* (the common garden pyrethrum) are all long-day plants.

The discovery by Garner and Allard that so-called short-day plants could be induced to flower earlier merely by shortening the day has led to wide application in horticulture. Prof. Alex Laurie, at Ohio State University, and Prof. Kenneth Post, at Cornell University, showed that commercial varieties of chrysanthemum could be brought into bloom several weeks ahead of their normal flowering time by putting black cloth over the plants late in the afternoon and removing it in the morning (see fig. 4). To conform with normal working hours the cloth is put on just before quitting time (around 5 P. M.) and removed in the morning between 7 and 8 o'clock. In the garden the same effect can be obtained by placing a cardboard box over the plant instead of the black cloth in the late afternoon and removing it in the morning. The box should be absolutely tight and pressed close to the ground so that all light is excluded. Since a day- and night-length favorable for bud formation in the garden chrysanthemum comes in this latitude about August 15, any treatment should begin before that day and be continued until the buds show color. Apparently, most varieties form buds about the same time but differ greatly as to the length of time required for their development, giving considerable spread in flowering time.

A plant which cannot form buds until the days are sufficiently short

Fig. 1. The effect of additional light on calceolaria. Plants on left lighted; plants on right not lighted. Photographed February 14. (From Laurie & Kiplinger, "Commercial Flower Forcing")

should respond to an artificial lengthening of the day by blooming later. This was found to be true provided a given variety was not delayed too long. However, when it was attempted to delay flowering until the winter months the plants often failed to produce buds as if some factor appeared in early winter to prevent the bud formation. This factor was found to be one of temperature. Prof. Post, of Cornell, showed that bud-formation was irregular if the night temperature dropped below 60° F. Temperatures below 60° at night are not likely during August or September (the natural time for bud formation) or earlier (if the buds are formed during artificially shortened days), but they often occur in the autumn or early winter when, through artificial lengthening of the day, the process of bud formation is delayed.

On the basis of this information one would expect a given variety of chrysanthemum to flower sooner in the south than in the north, as the days in the south are shorter during the summer. Professor Post has shown that varieties of the greenhouse chrysanthemums do not begin to form buds until the days have shortened to 14.5 hours or the night length becomes 9.5 hours. Since at Ithaca, New York, this comes about August 25, and at Miami, Florida, about July 20, the same variety of chrysanthemum would be expected to flower about a month earlier in Miami than in Ithaca. Actually, according to Professor Post, it flowers about a month later in Miami than in Ithaca. This apparent contradiction led to further experiments through which Professor Post was led to the conclusion that although buds begin to form when the days shorten to 14.5 hours, they cannot develop properly until the

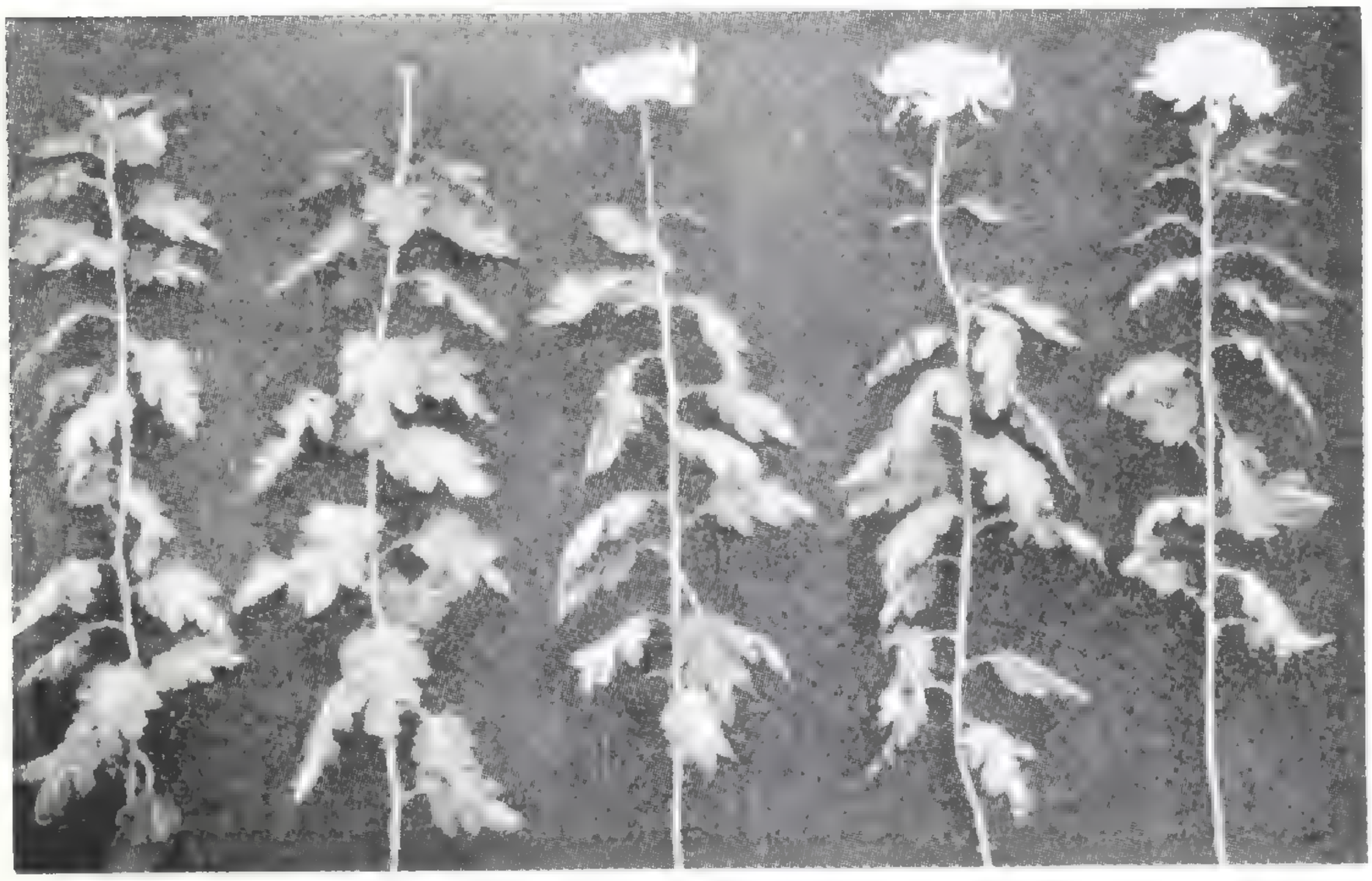


Fig. 2. Chrysanthemums showing stages in development of flower with successive periods of shading. (Oct. 1): *(Left to right)*: check, no treatment; shaded two weeks; shaded three weeks; shaded four weeks; shaded five weeks. (From Laurie & Kiplinger, "Commercial Flower Forcing")

Fig. 3. Effect of 4 hours additional light (background) for 40 days on feverfew. In bloom May 1. Foreground—check. (From Laurie & Kiplinger, "Commercial Flower Forcing")

Fig. 4. A method of shading with black cloth. (From Laurie & Kiplinger, "Commercial Flower Forcing")

days have shortened an additional hour. Further experiments have shown that it is not so much the day length that matters as the night length. In other words, the flower-buds begin forming when the night reaches a length of 9½ hours but they are unable to develop into flowers until the night is 10½ hours long or more. This night length refers to actual darkness, not merely the period between sunset and sunrise, for in the temperate zones the length of the twilight period is appreciable. For instance, if we consult the Sunrise and Sunset Tables issued by the St. Louis, Missouri, Weather Bureau, we find that a period of 9½ hours from sunrise to sunset should come around July 20. However, since there is an hour or so of twilight strong enough to prevent bud formation, it is not until about August 20 that this process really gets under way; and light conditions favorable for proper bud development probably will not come until about September 10 or 15. During a year of early frosts this means that tender varieties will not have much chance to really open up before they are killed. Chrysanthemum varieties, to be successful in this area, therefore, should have not only winter hardiness but frost-resistant flowers as well.

To emphasize how the chrysanthemum plant is influenced by light and temperature, let us go through the steps that would have to be followed to

flower a chrysanthemum out of season. If it is a variety that normally flowers about October 10 it can easily be made to flower as early as September 1 by shortening the day length, or as late as December 1 by increasing it. Since bud formation takes place in this area late in August (or about six weeks before normal flowering time), to promote early blooming, shading should begin not later than July 10 and continue until the buds show color. In order to make the variety bloom about December 1 additional light would have to be given from about August 15 to about October 15, after which the plants should be allowed to develop under natural day length. The temperature must be kept above a minimum of 60° F. during the night, otherwise buds will not develop. The additional light is usually supplied by ordinary electric light bulbs of 40–60 watts, placed about 2½ feet above the plants (fig. 3). Of course, if varieties naturally maturing during this period are available, little is gained by extending their flowering period, but certain other varieties are often better for specific purposes. In commercial practice a continuous production is required, but whether only naturally maturing varieties are used or others spread over a longer period by means of varying the day length artificially is a matter of net return per square foot.

Flowering the chrysanthemum in the spring is a little more involved than in the autumn and certainly more expensive. Nevertheless this practice will undoubtedly increase until overproduction reduces the prices to an extent that increased production is no longer economical. It seems reasonable to predict that within two or three years progressive nurserymen will be selling pot plants of good garden varieties in full bloom for Mother's Day or Decoration Day. These probably will not be so massive as autumn-blooming ones, but well-flowered plants in 4- or 5-inch pots would undoubtedly sell well during the spring holidays. Such plants would serve the same purpose as any other pot plant at the time and could afterwards be planted in the garden where they would bloom again in the autumn.

To flower chrysanthemums for Mother's Day or Decoration Day, the cuttings would have to be rooted during early January. At this time there are generally no cuttings to be had, for the stock plants from which cuttings would be taken are not in active growth due to low temperatures. Merely taking the plants into the greenhouse and giving them a temperature of 50–55° would not do, for although growth would be resumed at this temperature, the young shoots would have a tendency to produce flower buds due to the short days (or long nights) at this time of the year. It should be mentioned that while a 60° minimum temperature is required for the production of viable buds there is nevertheless, even at 55°, a strong tendency to a general slowing down of vegetative growth such as occurs when buds are

formed. To produce suitable cuttings, then, the stock plants should be given supplementary light so the night will not exceed nine hours. This treatment should be continued while the cuttings are being rooted and until about March 10. Around April 10, the plants should be given short-day treatment until the flower buds show color. Only from March 10 to April 10 could the plants be grown during natural day length. Expensive, you say? Yes, but not overly so when one considers the double satisfaction that would come from the plants produced in this way.

The reason chrysanthemums require a period of short days (long nights) before flower buds can be produced and developed is probably that a hormone required for flower production is produced during the dark period. Some plant physiologists believe that this hormone might some day be isolated and identified. If it can be artificially produced, we may be able to flower our chrysanthemums at will merely by spraying them with a hormone.

NOTES

Mr. George H. Pring, Superintendent of the Garden, and Mr. G. R. Lowrie, Orchid Grower, attended the meetings of the American Orchid Society, September 12–13, at Cleveland, Ohio.

Dr. Fred G. Meyer, who received his doctor's degree in the Shaw School of Botany in June, will sail for England in October to study at the Gardens of the Royal Horticultural Society at Wisley.

Recent visitors to the Garden include Mr. Ross H. Gast, of Los Angeles, who is investigating the history of *Hibiscus rosa-sinensis*; Mr. Grady Webster, graduate student in botany, University of Michigan, Ann Arbor; Mr. John Finan, graduate student in history of science, Harvard University; Miss Jeanne Morgan, graduate student, Ohio University, Athens.

The September number of the ANNALS OF THE MISSOURI BOTANICAL GARDEN (Vol. 36, No. 3) was issued during the month, containing the following papers: Evidence, excluding Mutations, Polysomy, and Polyploidy, as Possible Causes of Non-Mendelian Segregations in *Saccharomyces*, by Balaji D. Mundkur; New Species of *Lonchocarpus* from Panama, Frederick J. Hermann; A First Record of the Genus *Qualea* from Panama, Robert W. Schery; Some Pteridosperm Stems and Fructifications with Particular Reference to the Medullosae, Robert W. Baxter; Maize among the Hill Peoples of Assam, C. R. Stonor and Edgar Anderson.

THE MISSOURI BOTANICAL GARDEN

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SOME FACTS ABOUT THE GARDEN

The Missouri Botanical Garden was opened to the public by Mr. Henry Shaw about 1860. From that date until his death in 1889 it was maintained under his personal direction. Although popularly known as "Shaw's Garden" the name Missouri Botanical Garden was chosen by Mr. Shaw and he definitely indicated that he wished it called by that name. The Garden passed at his death into the hands of a Board of Trustees, designated in Mr. Shaw's will, and the Board so constituted, exclusive of certain ex-officio members, is self-perpetuating. By a further provision of the will the immediate direction of the Garden is vested in a Director, appointed by the Board. The Garden receives no support from city or state but is maintained almost exclusively from the estate left by Henry Shaw. Since 1939 many Garden Clubs and interested individuals have contributed to a "Friends of the Garden Fund" which is used in developing the new Arboretum, located at Gray Summit, Mo. The Arboretum (1) serves as a source of plants, trees and shrubs for the city Garden; (2) affords areas for gradually establishing a pinetum, a wild-flower reservation and various other features on a scale not possible in the city; (3) provides greenhouses for some 20,000 orchid plants.

The city Garden comprises 75 acres, where about 12,000 species of plants are grown, both out of doors and under glass. It is open every day in the year except New Year's Day and Christmas; week days, 8:00 a. m. until 7:00 p. m.; Sundays, 10:00 a. m. until 7:00 p. m. The greenhouses are closed every day at 5:00 p. m.

The main entrance to the Garden is at Tower Grove and Flora Place, on the Sarah bus line (No. 42). The Tower Grove bus (No. 21), direct from downtown, passes within three blocks of the main entrance.

MISSOURI BOTANICAL GARDEN BULLETIN

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Cover photograph by Paul Allen: The Durian fruit—"These are the sutures of the carpels, and show where the fruit may be divided with a heavy knife and a strong hand."—A. R. Wallace in "The Malay Archipelago."

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Missouri Botanical Garden Bulletin

Vol. XXXVII NOVEMBER, 1949 No. 9

THE DURIAN—A FASCINATING TROPICAL FRUIT

PAUL H. ALLEN

When the great Alfred Russel Wallace wrote his classic description of the famous Durian ("Durion," as sometimes called) some eighty years ago, this most exotic and controversial of the many fruits of the Asiatic tropics was almostly completely unknown outside of the Dutch East Indies. Thanks to the efforts of Dr. David Fairchild and Dr. Wilson Popenoe, the tree has been

DURIAN FLOWERS

"The flowers, which are produced in cymes, have a bell-shaped calyx and five oblong petals."—Wilson Popenoe in "Tropical and Subtropical Fruits."

DURIAN FRUIT

"The five cells are satiny-white within, and are each filled with an oval mass of cream-colored pulp, imbedded in which are two or three seeds about the size of chestnuts. This pulp is the eatable part and its consistence and flavor undescribable."—A. R. Wallace.

introduced into our hemisphere, and lofty specimens are now to be found at the Fairchild home in Florida, at Lancetilla, the United Fruit Company's experiment station in Honduras, and the Plant Introduction Gardens at Summit, in the Canal Zone.

The ripe fruit has an overpoweringly disagreeable odor, yet the native Dyaks of the East Indian forests are extremely fond of it, and many European residents in those islands deliberately arrange their home leave so as not to miss the Durian season. Whether it will ever become so popular in the Americas is problematical, yet there can be no question that it is one of the most fascinating of all tropical fruits.

Note.—Paul Allen writes in a letter to the Director of the Garden:

"On the occasion when the pictures of the fruiting specimens were taken, I had been on a short exploratory drive through the Summit Gardens grounds in my car, a small coupe, with a closed turtle back. Knowing the Durians should be nearly ripe, I got out to look under the trees, and found the entire crop of some five or six fruits on the ground, one of which had been hacked to pieces by one of the laborers. Since I knew the administration was anxious to save the seeds, I picked up the lot (with some difficulty, since the heavy, armoured fruits make quite a handful) and put them into the back of the car, thinking the while that the famous smell had been considerably over-rated. The drive to the office was short, but the morning hot, and by the time I arrived I had frankly had about enough Durian, at least in such close quarters. Once spread out in the air, however, they became much less offensive, though carrion flies were attracted immediately and all of the Summit staff promptly retreated to the office, while the nurseryman and I opened the lot and took photographs. We found the flavor to vary a great deal in the length of each segment, the pulp surrounding the central seeds being decidedly rank and garlicky, while the riper pulp about the terminal seeds was much more mellow and custard-like. The curious, and possibly unique feature in eating Durians (besides the terrific effluvium) is the delightful, and almost indescribable after-taste, which becomes effective a few seconds after swallowing the first bite, and quite unlike the initial taste sensation."

Supplementary Notes

ROBERT W SCHERY

The genus *Durio* of the Bombacaceae family contains a few species of tropical trees native to the rain forests of the Malay area and the East Indies. A single species, the Durian, *Durio zibethinus*, has found favor as a fruit tree only within recent decades introduced into this hemisphere. Yet some half dozen other species are acceptable timber trees of the Far East, and the bark and seeds of one are used medicinally in Sumatra.

As can be seen from Paul Allen's photographs, the Durian tree attains considerable proportions. Nevertheless it is reported to start fruiting when only about seven years from seed. Most trees are raised from seed (the species can be budded), although only modest effort has been made to select seed for better fruit. Nevertheless the semi-cultivated Durian trees in the East often gain considerable local reputation where the fruits are unusually flavorful. Such fruits may be carried greater or lesser distances and their seeds thus haphazardly spread though not actually planted. Durian fruits do

THE DURIAN TREE

"The Durian grows on a large and lofty forest tree, somewhat resembling the elm in its general character but with a more smooth and scaly bark."—A. R. Wallace.

not keep well, and seldom can be transported more than a day or two from their source. Even attempts at cold storage have met with only limited success. Where man does not accept the gift of forest Durian fruit, forest animals are almost certain to.

The large Durian fruits (see Allen's photographs) are borne upon moderately stout branches. When ripe they offer considerable hazard to any unwary passer-by, but in falling seldom break because of the thick, tough rind. So heavily spined are they that picking one from the ground by other than the fruit stalk is difficult and painful. Durian fruits differ markedly in size, shape, length of spines and (objectionable) aroma, although the latter is more a reflection of age than inherent qualities. The comestible portion is the fleshy aril surrounding the seeds, which in better strains is creamy-yellow and sweet. Seldom do writers agree in attempting to define the taste of this aril, and most of a certainty the taste will vary as the fruit ages. Alfred R. Wallace gives the most famed description of the taste as: "a rich butter-like custard highly flavored with almonds, but intermingled with it come wafts of flavor that call to mind cream-cheese, onion-sauce, brown sherry and other incongruities. Then there is a rich glutinous smoothness in the pulp which nothing else possesses, but which adds to its delicacy. It is neither acid nor sweet, nor juicy, yet one feels the want of none of these qualities, for it is perfect as it is."

Apologists for the Durian suggest that the fruit be eaten soon after it falls, before chemical change develops garlic-like overtones, while at the other extreme Durians buried and fermented many days have appealed to native tribes. Durians are usually consumed fresh, but may be cooked and in times of abundance are frequently made into conserves or salted. The seeds, too, may be eaten boiled or roasted, and other parts of the plant are used medicinally or the ashes serve as a dye.

THE PERSIMMON—A LONG-NEGLECTED FRUIT

A. P. BEILMANN

The dry, sun-baked hills of the Middle West produce tons of a delectable fruit which is ordinarily completely ignored. Many abandoned fields in this section spring up with a cover of sassafras and persimmons, and while the sassafras has had its share of publicity extolling its virtues as a spring tonic, the persimmon has had few champions.

The common persimmon *(Diospyros virginiana)* is of botanical interest since it is the only northern member of the plant family Ebenaceae, most all the others growing in the tropics. Individual trees bear both staminate (male)

and pistillate (female) flowers, but normally these are so well distributed that almost any persimmon will bear a crop of fruit. The tree is notoriously hard to transplant; in fact, it would be quite difficult to give successful planting directions. Ordinarily its tap-roots must not be disturbed despite the fact that the tree is an invader of abandoned fields and perfectly capable of establishing itself anywhere.

Branch and fruit of the common persimmon *(Diospyros virginiana)*

In Farmers' Bulletin No. 685 (U. S. Dept. of Agr., 1915) fourteen varieties of the native persimmon are listed. Two of these were found in Missouri, which indicates that the plant was of considerable interest at one time. Quite a number of the varieties have been grown at the Arboretum; "Ruby", "Hicks", "Josephine", and "Early Gold" have been grafted on established seedlings. In addition, a number of other unnamed selections have been tried. Mr. John Howe of Pacific, Mo., has top-worked "Early Gold" in a number of his trees, and Dr. Hermann von Schrenk, of Florissant, Mo., has forwarded a number of seeds of early-ripening varieties. These trees have not reached maturity.

Those immense persimmons found on the market in late fall are usually the Japanese species *(Diospyros Lotus* and *D. Kaki)*. Many named varieties of these are available, and a number have been tried at the Arboretum. So

far none have produced fruit, and until hardier varieties are developed the Japanese Persimmon can be dismissed as unsuited to this region. Usually the fruit on these species is very poor in quality, but they have the size and the color deemed necessary for establishment as a commercial fruit. On the other hand, the native persimmons are almost all edible, although they are by no means alike in attractiveness and palatability.

Considerable variation can be observed in the native persimmon on almost any hill side. It is the writer's experience that the sweetest and largest fruits are those which ripen earliest. In fact, those persimmons which ripen long before frost and fall before the leaves are ordinarily of better quality than those which ripen after a frost and after the leaves fall. Often both types can be found on the same field or ridge top. If you like persimmons pick those which ripen before frost. If you have a choice, take the fruit from a young vigorous tree and leave the small, rather dry, late-ripening fruits on the big trees for the wild life.

Most persimmons are eaten as they are shaken off or picked up under the tree. It is somewhat difficult to store or to keep them, and usually one can not eat many at one time for the fruit quickly palls no matter how tasty the first few were. Most of the harvesting is done by wild life, the persimmon being a staple part of the diet of many of the larger animals. Wolves, for instance, will eat some persimmons every day as long as they are available.

With hundreds of pounds of fruit available for the picking on many Missouri hill sides it would seem that some investigation of the utilization might be in order. Persimmons can not be kept at room temperature; they quickly lose moisture and palatability at high temperatures; and they tend to dissolve into a soggy mass under refrigeration. An effort will be made to quick-freeze a test lot this year. Perhaps at a very low temperature they will retain their fresh flavor and character.

Persimmons have not been generally used in cookery, but the following recipes indicate that this fruit can be used successfully. The recipe for persimmon pudding has been in the family of Mrs. J. C. Carter of Urbana, Illinois, for many years, and the persimmon pie is one of her favorites.

PERSIMMON PIE

Wash and cut one large Japanese Persimmon or an equal quantity of native persimmons and run the pulp through a strainer. Bring 2 cups of milk to the scalding point in the top of a double boiler. Add 1⅛ cups of sugar sifted with 1 tablespoon of cornstarch, stirring all the time. When this thickens, add ½ teaspoon of salt and pour a little of the hot mixture over two beaten egg yolks. Add the eggs to the milk and continue cooking the custard for a few minutes. Then add the persimmon pulp, and pour into a baked pie shell. Cover with a meringue made of 2 stiffly beaten egg whites and 4 tablespoons of sugar. Place the pie in a 350° oven and bake it for 15–20 minutes to heat the meringue through.

PERSIMMON PUDDING

To 1 quart of persimmons rubbed through a colander, add ½ teaspoon soda and stir in well. Cream 2 cups of sugar (scant) with 2 beaten eggs. Mix 1 quart of milk, 1 quart of flour and 2 teaspoons baking powder. Pour in persimmons and stir all together. Bake in a gallon crock set in a pan of hot water with a pan of hot water on top. Bake four hours.

Mrs. Carter adds that the pudding can be processed and packed in jars. However, she prefers using a crock with water above and below even when using an electric oven.

THE PERSIMMON TREE

JULIAN A. STEYERMARK

The persimmon *(Diospyros virginiana)* is considered to be the first native American fruit to be described by early explorers of this continent. As early as 1557 De Soto published an account of it. Because it is generally so well known and abundant in Missouri, people are apt to take it much for granted. Its relative, the Japanese Persimmon or Kaki Plum *(Diospyros Kaki)* is the large-fruited type found in various markets. However, the taste of the oriental species, growing wild in China, Japan, and Korea, is usually considered to be quite inferior to that of the deliciously sweet common persimmon. The latter, also known as "Possum-wood" because it is one of the favorite foods of the opossum, is eaten by many other animals, including wolves, hogs, and horses. The scientific name, Diospyros, derived from the Greek, *Dios*, God, and *pyros*, grain, refers to the edible quality of the fruit. But woe be to the person who bites into an unripe persimmon! The astringent, puckery feeling caused by the large amount of tannin present is something not to be forgotten.

While there are more than 200 different species of persimmon, practically all of them found in tropical and subtropical regions of both hemispheres, only two species *(D. virginiana* and *D. texana)* are indigenous to the United States. *Diospyros texana,* often known as the Black Persimmon, is native to Texas and northern Mexico. Its fruit has a thin, dark, sweet flesh, but cannot compare in flavor or size with that of *D. virginiana,* the common persimmon. The common persimmon is found wild from the southern states northward to Connecticut, New York, Pennsylvania, Ohio, Indiana, Illinois, and southeastern Iowa, and reaches its western limits in eastern Kansas and Texas.

Although the distribution of the persimmon is at present restricted northward, fossil records indicate that the genus was truly world-wide millions of years ago, occupying territory as far north as Siberia, Alaska, and Greenland. It is an ancient genus, and can be traced in the fossil records as far back as Cretaceous times. The leaves of the extinct species were very similar in shape, size, and veining to those of the common persimmon. Drastic

Fig. 1. Dwarf persimmon on limestone "barrens" in southwestern Missouri. (Photograph by Cora S. Steyermark)

changes in climate and topography over past geological periods have brought about the present geographical distribution of the group.

The common persimmon is quite a variable species, differing in tree stature, leaves, and fruit. In Missouri, where most of the variations are found, the mature persimmon ranges from immense forest trees to dwarf specimens less than shoulder high. In the rich bottom-lands of the Mississippi River in Big Oak Tree State Park and vicinity (Mississippi County), the persimmon trees attain a height of 150 feet and a trunk diameter of nearly 3 feet, while on the barren limestone "bald knobs" of southwestern Missouri, they are only about 3 feet tall and only a few inches in diameter (fig. 1). One might suppose that these dwarf trees were only immature ones, but year after year they bear fruit. The adverse growing conditions on these glades or "bald knobs" have kept them stunted. Such dwarf plants may offer con-

siderable possibilities for the breeding of early-maturing varieties if the day ever arrives when our native persimmon assumes commercial importance. Actually, it is surprising what little attention has been given to the cultivation and improvement of this native fruit. At present, it is seldom seen in the usual markets, since, once ripe, the flesh softens and damages easily, making the fruit difficult to transport. It has high food value, being exceeded only by the date according to a survey showing the food value of various fresh fruits.

There is a luscious flavor to the persimmon, and some day, with improved transportation facilities and breeding of superior races, it may attain the prominence that it well deserves. Early explorers described the fruit as a "delicious little plum," while in the seventeenth century it was said by John Smith to resemble a plum with the flavor of an apricot. Judging by the many enthusiastic pickers who each year seek out the trees at ripening weather in the autumn, it would appear that the persimmon has a popular appeal. Besides being eaten whole as a fresh fruit, it can be prepared in a number of ways—in puddings, ice cream, griddle cakes, muffins, cake, and candy. It may also be preserved by drying in sugar. The American Indians used the pulp of the fruit mixed with corn to make a type of bread.

Many trees ripen their fruits before frost, but in some strains the fruit is ripe only after it has been nipped by frost or low temperatures. The skin of the persimmon is orange-yellow or salmon with a silvery or bluish-gray coating which becomes bluer as the fruit matures or is frosted. While the flesh of most native persimmons varies from pale to deep orange, a specimen is rarely found with nearly black fruit. This is *Diospyros virginiana* forma *atra,* in Missouri known only from upland woods in St. Clair County.

The persimmon grows in about two-thirds of the counties of Missouri. It is found throughout the southern and central parts of the state, and infrequently northward in Gentry, Linn, Macon, and Marion counties. The leaves of the common type are smooth and hairless on the lower side, but in variations they are hairy. The dwarf type is forma *pumila.* Varieties *platycarpa* and *pubescens* differ from the common type in period of ripening, color of fruit, and shape of leaves.

The wood of the persimmon is hard and strong, and, when old, turns brown or black. The ebony of commerce is obtained from various oriental species of Diospyros, especially *D. Ebenum* and *D. Ebenaster,* noted for the hardness and jet-black color of the heartwood. The wood of the common persimmon is used in the manufacture of bobbins, shuttles, shoe-lasts, plane-stocks, and in turnery.

In Missouri the persimmon is a pioneering species, being one of the first trees to invade old fields or rocky limestone "barrens." In upland pastures

and open ground of Ozark ridges it commonly forms small stands. From a single tree long surface roots extend through the soil and send up many sprouts or suckers. These continue the spread from the original tree until eventually a thicket results. In this respect the persimmon resembles the sassafras. Although attaining its maximum dimensions in fertile bottom woodlands, the tree fruits most abundantly in open exposed situations.

CRAWFISH FLAT

LOUIS G. BRENNER, JR.

In the selection of names for the various distinctive areas of the Arboretum it is only fitting that the most peculiar characteristic of that area be incorporated in the name to be chosen. Local names in common usage are often colored with the landsman's simple taste for the things he meets and sees in his daily life. Within the Arboretum is a distinct soil type lying as a high terrace bordering the south bank of Brush Creek. Here the sandy Robertsville Silt Loam is underlain by an impervious "hardpan" of heavy clay and causes a marshy condition during most of the year. Such a wet soil provides an ideal habitat for various lower animals, especially Crustacea so fondly known to the natives as "Crawfish" or "Crawdads." The large numbers of these animals that live in these cold wet soils is evidenced by the numerous "castles" or "chimneys" which they build to aerate their chambers, or from which they may make their nocturnal quest for food. To the natives such a soil is known as "Crawfish Soil," which is an accurate and simple name for such a distinct soil type. With this in mind we have given the name "Crawfish Flat" to the broad terrace bordering Brush Creek.

Because of the poor subsurface drainage the crawfish soils remain wet and cold until well into the summer. It is understandable then that the flora supported by this soil should consist of summer- and autumn-flowering species, of considerable interest primarily because in their moist habitat they offer color in a season when all else is parched by late summer drought and winds.

Soils and flora are not the only interesting features of Crawfish Flat. It may also be looked upon as an example of carefully planned land management resulting in the reestablishment of important members of our native flora which could not compete against a program of intense land usage. Recent years have seen a marked increase in the lovely winged loosestrife *(Lythrum alatum)*, absent for some time in this area. Following an exceptionally wet season and, in the protection of the rank vegetation, the large blue lobelia *(Lobelia siphilitica)* is at its best. The swamp milkweed *(Asclepias incarnata)* is a recent arrival on Crawfish Flat, where some two dozen plants form massive clusters of the tiny pink florets. A more complete listing of

new additions to the flora of the "flat" will also include ragwort *(Senecio* sp.), sneezeweed *(Helenium autumnale)*, and ladies' tresses orchid *(Spiranthes lucida)*.

Crawfish Flat is referred to as a "cut-over swamp pasture" since it bears close resemblance to the "gall" areas of the southern swamp regions and because pasturing is resorted to in the routine maintenance of the area. The low crown and broad spreading habit of the ancient trees bordering the flat indicate than an open, park-like condition prevailed under the virginal conditions of earlier generations. It is hoped that in the addition of selected moisture-loving trees this original condition might be restored.

THE HERB GARDEN OF THE SHAW SCHOOL OF BOTANY

MARY LOUISE FITZ-GERALD*

No one is quite certain who built the Hanging Gardens of Babylon, but we have reason to believe that some of the plants that flourished there live in our time. In a new garden which has been just finished at the corner of Rebstock Hall, Washington University, there may occur some of the same fragrant plants that Sennacherib's Nubian wives longed for—or were they Nebuchadnezzar's?

This neat little garden is approximately 20 × 40 feet. It is well labeled and has attractive brick paths and a marble bench. The plan of the garden is simple and one of the oldest in history, having been mentioned in the most ancient literature of the Hindus (the Vedas). There are four oblong beds, symbolic of the four seasons and four winds of heaven. Even the Garden of Eden had "four rivers to water it." The brick paths form a cross, symbolic of the cosmic cross. To the Eastern mind, symbolism was paramount —more important than the plants themselves. It seems fitting that we should pay attention to the symbols and legends of the ancient plants now growing in the new garden.

One bed is bordered with French Thyme *(Thymus serpyllum)*. It is on the leaves of this that fairies have always rested their babies whilst cavorting in the moonlight. A second bed is bordered with Dwarf Bush Basil *(Ocimum minimum)*. These little green footballs, the leaves of which are so pungent, are one of the sources of old love potions, supposed to engender undying affection when properly used. In another border is Sweet Marjoram *(Origanum Majorana)*, featured in history as one of the herbs used at

* Mrs. Charles Fitz-Gerald has for some years served as a voluntary greenhouse assistant in the Henry Shaw School of Botany. She is, among other things, a member of the St. Louis unit of the Herb Society of America and one of the national officers of that organization. During the spring and summer of 1949, largely as a result of her efforts, a charming herb garden with brick accessories was created. Visitors will find it conveniently located near the Forsythe Avenue parking lots at Washington University.

View of the Herb Garden of the Shaw School of Botany at Washington University

coronations by the herb-strewers—very important persons in the Middle Ages. The little evergreen Teucrium *(Teucrium Chamaedrys)* occupies the fourth border. The old herbarists called this "the most principal herb for borders and in making knot gardens" (carefully designed figures formed from miniature hedges).

There are twelve large plants which will eventually screen the stone foundation of the greenhouse. One is Elecampane *(Inula Helenium)*. Helen of Troy is reputed to have carried a flower of this plant when she was stolen by Paris. Costmary or Bible-leaf *(Chrysanthemum Balsamita)* marked the place in bibles, and the balsamic scent revived our sleepy colonial ancestors sitting through long sermons. Angelica *(Angelica Archangelica)*, too, is there, its stalks often being used even now in candy or cakes in northern

View of north part of Herb Garden

Europe. The tall plant, Lovage *(Levisticum officinalis)*, which smells and tastes like celery, Tansy *(Tanacetum vulgare)*, from which tea is made, and Sweet Mugwort *(Artemesia lactiflora)*, are all in the background.

According to Pliny and Dioscorides, herbs were cared for in monasteries and convents, and when women of the village went out in search of herbs they were thought of as witches. Today it is hard to imagine how important it was in former times to have herbs to strew on the floors. Before banquets or when royal guests suddenly appeared, servants were sent scurrying about to provide sweet-smelling herbs in an age when hygiene and cleanliness were little considered.

Lavender *(Lavandula officinalis)* in Roman days perfumed the baths, the name being derived from the Latin *laver*, meaning "to bathe." Lavender flourishes in England in the chalky soil. One may easily visualize the old castles of that island where large bowls of lavender were set to dry in large rooms. Miss Eleanour Sinclair Rohde, the noted English herbarist, has told a fascinating story in her book "Herbs and Herb Gardening":

> To my thinking the fragrance of Lavender seems to absorb in some mysterious fashion memories of those who in past centuries dwelt in the place. . . . A group of people were seated on the lawn of an old castle in Scotland. Suddenly a few of them noticed that the shutters of a window were being opened. A comely young woman in the servant costume of about two hundred years ago was opening them and this done she leaned on her elbows on the window-sill and placidly looked out. . . . She seemed utterly unaware of the people seated there. After a few minutés shè withdrew and closed the shutter. That is all. . . . But the bowls of Lavender that have been exposed for some months in these rooms have to my senses absorbed some influence from unseen presences . . . compared only to a photographic sensitive plate.

Rue *(Ruta graveolens)* is distinctly a medicinal herb used in the old days to ward off disease and evil spirits. A judge would not hear a case without a spray of rue in his hand, waving it constantly between himself and the miserable offender. As for sage *(Salvia officinalis)*, again Pliny wrote: "Who that useth to eat of this herb or drink it, it is marvel that any inconvenience should grieve them." Betony or Lamb's Ear *(Stachys betonica)* was a sovereign remedy for many ills. "If a man become tired in mickle going, let him take betony." Also it was a shield against "monstrous nocturnal visitors." All of these herbs are to be found in the new herb garden.

There is also a soft gray feathery herb named Roman Wormwood *(Artemesia pontica)*. Sweet Woodruff *(Asperula odorata)*, we shall have growing in the shade, and without which the legendary German drink for May Day could not be made. And there is Tarragon *(Artemesia Dracunculus)*, called Estragon, because the roots look to be little dragons. The Sacred Basil *(Ocimum basilicum)* is growing nicely, most revered plant of the Hindus. All of the true faith, when they die, have a spray of this basil placed in the hands. If this be given to the keeper of the Gates of Heaven there is received in return a key with which to enter.

Clary Sage *(Salvia sclarea)* has seeds used to clear the eyes, much as we sometimes use flax seed. It was also called Clear-Eye. Borage *(Borago officinalis)* "brings awlaies courage." It is grown as a bee forage and the blue flowers are often floated in wine on ceremonial occasions. Monarda *(Monarda didyma* is one of the few herbs with colorful flowers. The Indians of our West gathered Monarda in wagon loads to bring to the villages. It was used almost as we do money. The Rosemary *(Rosmarinus officinalis)*, with light blue flowers, is said in legend to have been formerly white. When Joseph and Mary were fleeing to Egypt with the Child, she laid her blue cape over White Rosemary. Since then the flowers have been blue—or so is the legend. And mint *(Mentha spicata)*, said a ninth-century writer, has as many varieties as there are sparks from Vulcan's furnace. We have a few sparks outside the garden. A crown of fresh mint is said to stimulate the mind and is on trial by the writer as this is written.

Few trees can recover their beauty after they have been repeatedly cut back but the sycamore seems to thrive on it. Perhaps this is because it is repeatedly pruned under natural conditions, losing its branches in windstorms.

The flowers of our native aloe, *Agave virginica*, are blue-green and seal-brown and of no particular beauty when seen out of doors. Bring them home, however, and display them against a neutral background and see what charm they suddenly take on.

NOTES

The annual Chrysanthemum Show at the Garden was opened to the public on November 7 and will continue throughout the month.

Mr. A. P. Beilmann, Arboriculturist to the Garden, has returned from a collecting trip to Montana, where he went in search of conifers suitable for the climate of Missouri.

Among the groups who held meetings at the Garden recently were the Tree Lovers Group of St. Louis, and the mid-western section of the Garden Club of America.

Mr. Ladislaus Cutak, in Charge of Succulents, served as judge of the Nature Division in the annual Print and Color-slide Exhibition of the Photographic Society of America, held in St. Louis, October 1 and 2.

Recent visitors to the Garden include the following: Dr. A. R. Davis, Dean of the School of Liberal Arts, University of California, Berkeley; Mr. Norlan Henderson, graduate student, University of Indiana, Bloomington; Mr. Robert Barton, Landscape Gardener, West Palm Beach, Florida; the students in landscape architecture from the School of Architecture, Washington University.

If you have a rose bush which is covered with bright red fruits (or hips, as rose-growers call them) you may be interested to know that these are good to eat and have a high vitamin content. Boil them just as they are, put them through a collander or sieve to take out the seeds, add sugar, cook a few minutes longer and serve them as a fruit-sauce or fruit-butter.

The autumn of 1949 has been one of generally poor coloration in the St. Louis area. Perhaps this is because of rather moist weather in which cold snaps have been infrequent and with little or no frosting. The usually outstanding early colorers—sassafras and sumac especially—passed with little notice. The somewhat later and ordinarily spectacular hard maple was generally not its usual self. Hickories and ashes, in most years contributing a modest yellow to the deciduous forest, lost their leaves early with little coloration. Only the late colorers—especially the oaks and sweetgums, which held their leaves into November—seemed to profit by the brisk weather during the last week of October. Neither oak nor sweetgum is as brilliant as the earlier coloring trees mentioned, but the browns and reds of a dense stand of oaks seen reflecting a low, full sun in the early morning or evening still gave Missouri a late October and early November taste of the autumn glory of a deciduous hardwood forest belt.

THE MISSOURI BOTANICAL GARDEN

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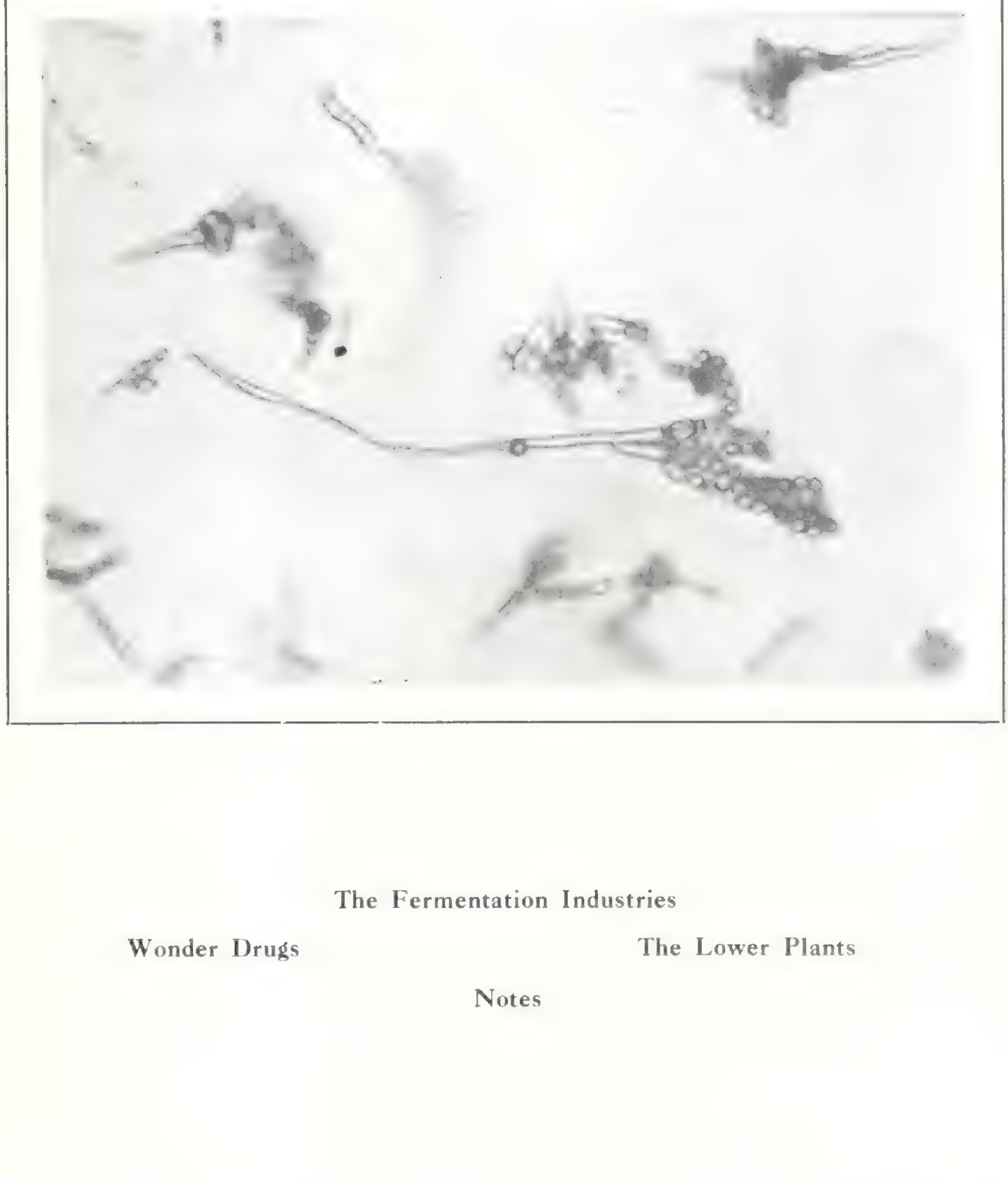
SOME FACTS ABOUT THE GARDEN

The Missouri Botanical Garden was opened to the public by Mr. Henry Shaw about 1860. From that date until his death in 1889 it was maintained under his personal direction. Although popularly known as "Shaw's Garden" the name Missouri Botanical Garden was chosen by Mr. Shaw and he definitely indicated that he wished it called by that name. The Garden passed at his death into the hands of a Board of Trustees, designated in Mr. Shaw's will, and the Board so constituted, exclusive of certain ex-officio members, is self-perpetuating. By a further provision of the will the immediate direction of the Garden is vested in a Director, appointed by the Board. The Garden receives no support from city or state but is maintained almost exclusively from the estate left by Henry Shaw. Since 1939 many Garden Clubs and interested individuals have contributed to a "Friends of the Garden Fund" which is used in developing the new Arboretum, located at Gray Summit, Mo. The Arboretum (1) serves as a source of plants, trees and shrubs for the city Garden; (2) affords areas for gradually establishing a pinetum, a wild-flower reservation and various other features on a scale not possible in the city; (3) provides greenhouses for some 20,000 orchid plants.

The city Garden comprises 75 acres, where about 12,000 species of plants are grown, both out of doors and under glass. It is open every day in the year except New Year's Day and Christmas; week days, 8:00 a. m. until 7:00 p. m.; Sundays, 10:00 a. m. until 7:00 p. m. The greenhouses are closed every day at 5:00 p. m.

The main entrance to the Garden is at Tower Grove and Flora Place, on the Sarah bus line (No. 42). The Tower Grove bus (No. 21), direct from downtown, passes within three blocks of the main entrance.

MISSOURI BOTANICAL GARDEN BULLETIN



The Fermentation Industries

Wonder Drugs

The Lower Plants

Notes

Volume XXXVII December, 1949 Number 10

Cover: Showing brush-like structure of *Pinicillium notatum*, the source of penicillin. Magnified about 600 times. Photographed by Yamada and Rodenberg.

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Missouri Botanical Garden Bulletin

Vol. XXXVII DECEMBER, 1949 No. 10

THE FERMENTATION INDUSTRIES

PAUL L. PAVCEK

The industrial use of microorganisms so small that they must be magnified at least 100 times before they can be seen by the human eye is a common occurrence in our every-day life. It is nothing new to us to see an ordinary cake of yeast, when added to flour and water, produce carbon-dioxide gas which causes the dough to rise. We know that crushed grapes, when allowed to stand in a warm place, will soon undergo fermentation and the juice turn to alcohol. The above are simple examples but there are a multitude of industries which employ such tiny plants to produce commercially important by-products using primarily sugar as the starting material. The microorganisms which effect this conversion of sugar to valuable by-products are numerous but all of them can be classified as either bacteria, yeasts, or molds. These three categories of microorganisms and the industries depending on them are briefly discussed on the following pages.

Yeast Fermentation.—When a cake of yeast is suspended in a pint of water containing an ounce or so of sugar, bubbles of gas will be seen rising in the vessel in several hours, and in 24 hours the solution will be almost free of sugar, but with a definite odor of alcohol. The great French bacteriologist, Louis Pasteur, first recognized this phenomenon as a "fermentation" and accounted for the change by the following formula:

$$\text{Sugar} + \text{yeast} \rightarrow \text{alcohol} + \text{carbon dioxide}$$

Because of this reaction the production of beer, wine, and industrial alcohol is possible. If the sugar-yeast solution is subjected to continuous aeration by merely blowing air into it, much smaller amounts of alcohol and carbon dioxide result and instead the yeast cells grow and multiply. By this modification of aerating the yeast-sugar suspension the "bakers" yeast industry has developed. Of course, in order to produce large amounts of yeast from a small amount of seed, a source of nitrogen for protein synthesis must be added. This is easily achieved by use of ammonia or ammonium salts. The

yeast thus produced is conveniently harvested by pressing through frame presses and is either sold in the compressed form for use in baking of bread, or dried and sold as pharmaceutical yeast as a source of protein and of B-vitamins.

During the last war Germany exploited to the utmost the use of yeast as a human food. Faced with the problem of feeding the population without recourse to her usual imports, Germany began the growing of various types of yeast on a variety of sugar solutions. A very cheap nutrient for certain strains of yeast was the waste liquors from the manufacture of paper pulp. These so called sulphite-waste liquors contained about 5 per cent fermentable

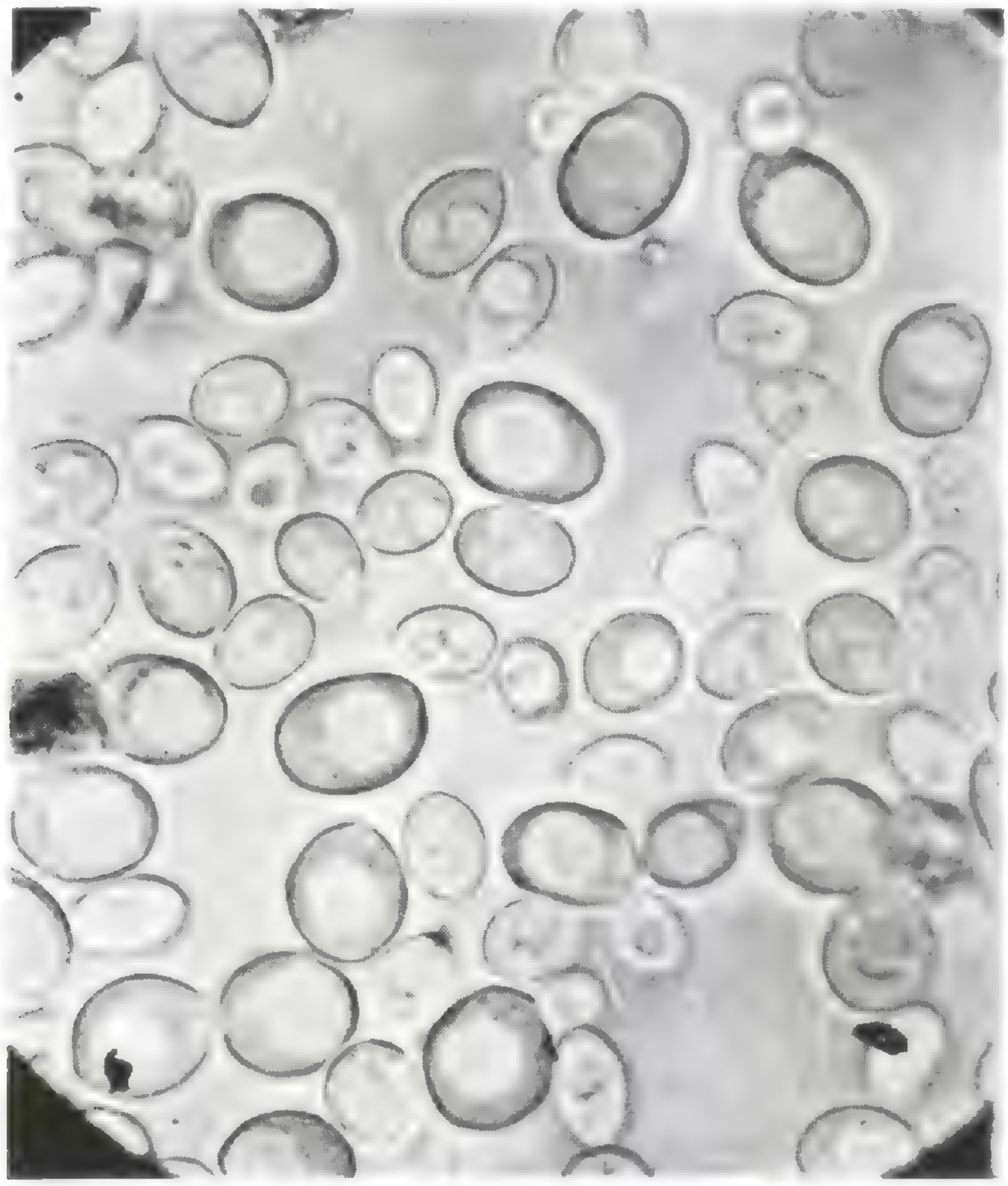

Fig. 1. *Saccharomyces cerevisiae*, the yeast used by brewers and bakers. Magnified about 1000 times.

sugar and were used extensively for the manufacture of yeast which was dried and incorporated into soup mixes, gravies, and bread spreads. The German Army used large amounts of dried yeast in their rations, and at the end of the war some 200 factories were engaged in this type of yeast production and utilization.

Bacterial Fermentations.—Certain bacteria which can be obtained from soil are capable of growing on cooked corn mashes to produce substantial amounts of acetone and butyl alcohol. Just how the bacteria split the sugar

molecule to obtain these products is a bit too complicated to discuss here, but the use of these products as lacquer solvents in the manufacture of "Duco" enamels has certainly revolutionized the painting of automobile bodies. The bacteria responsible for this fermentation are specialized organisms which are called anaerobes (from *an*, "not" + *aero*, "air" + *bios*, "life") because they grow only in almost complete absence of oxygen. *Clostridium acetobutylicum* is the name of one organism which is used commercially.

The souring of milk is a phenomenon known to the housewife as well as to the bacteriologist who has identified the bacteria responsible as the "lacto bacilli." These bacteria use lactose (the sugar in milk) and produce lactic acid which is responsible for the acid taste of sour milk. This lactic acid fermentation has further application, since it plays a major role in the

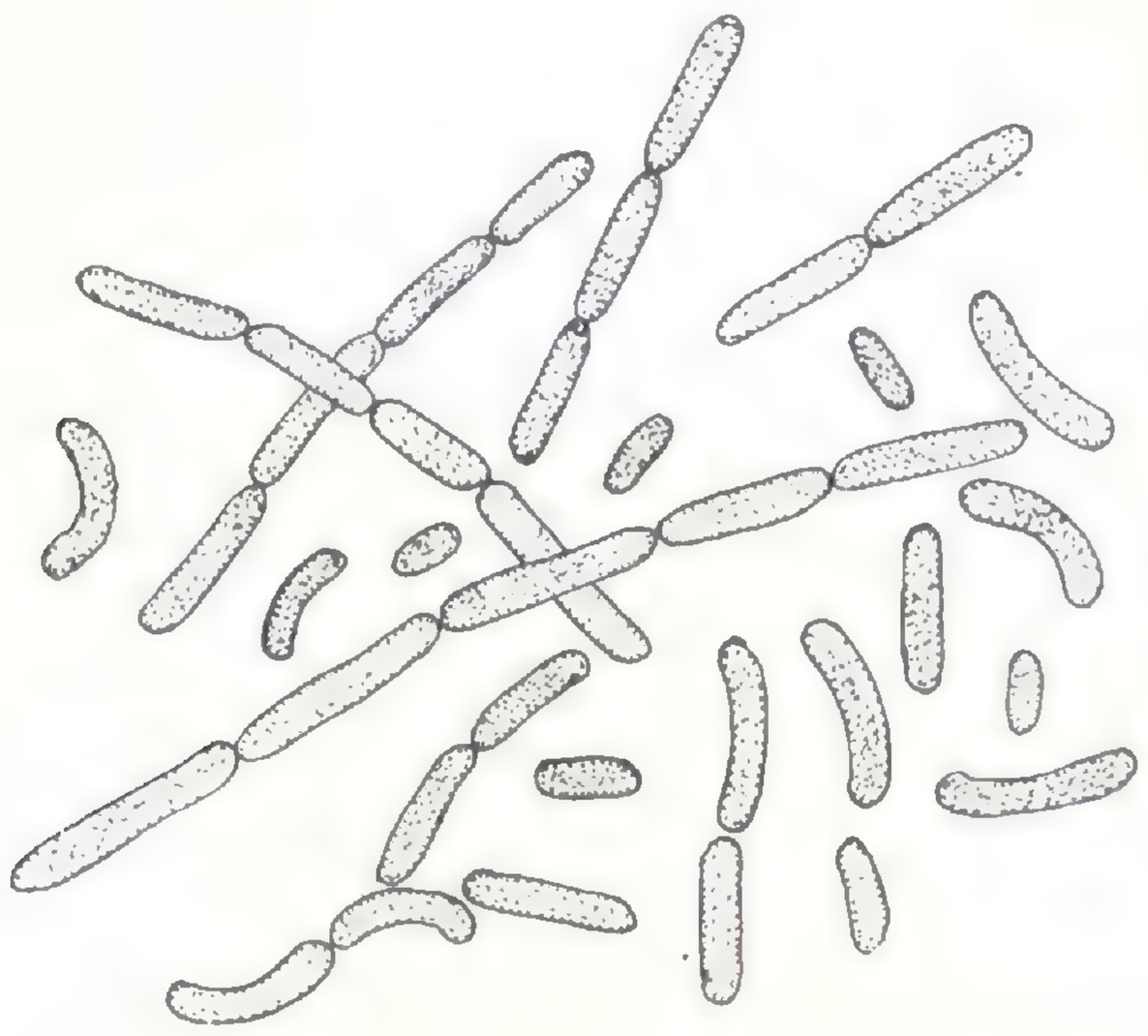

Fig. 2. *Lactobacillus lactis*, found in sour milk. Magnified about 1000 times.

cheese-making industry. The curd produced in the souring of milk is filtered off, and this proteinaceous material further converted, during the ripening and curing steps, to simpler compounds more easily assimilated by the body—all achieved by the lactic acid organisms which are present. Molds also are concerned in the ripening process, and the distinct flavor of Roquefort and Camembert cheeses is due primarily to products elaborated by special molds which grow in the later stages of their manufacture.

Sauerkraut is cabbage which has been fermented by lactic acid-producing bacteria such as *Lactobacillus mesenteroides*. Sauerkraut usually contains at least 1.0 per cent of lactic acid. Essentially the same lactic-acid organisms are responsible for such products as pickles and olives, and here again the superior keeping qualities of these foods is due to their high content of lactic acid.

The manufacture of lactic acid in pure form is still accomplished by means of bacterial fermentation of sugars. In the manufacture, various strains of lactic acid-producing bacteria are grown on sugar-malt sprouts media. After 24–48 hours of fermentation conducted at 100° F., which is the optimum temperature for maximum acid production, powdered limestone is added to form the insoluble calcium lactate from which the lactic acid is liberated by adding sulphuric acid. The uses of lactic acid in the food industry are many, ranging from use of the acid to supplement the natural acidity of fermented foods such as sauerkraut and olives to the curing of meats and manufacture of effervescent beverages. Calcium lactate is used in the manufacture of bread and as a constituent of baking-powders. Iron lactate can be used as a source of "available" iron in the enrichment of foods. Even the tobacco grower finds use for the calcium salt of lactic acid to aid in moisture retention. Esters of lactic acid are excellent solvents in the manufacture of lacquers and plastics.

The farmer is also indebted to microorganisms, chiefly of the lactic acid-producing variety, in making possible certain silages used as food by cattle. The green corn plant, containing preferably not less than 70 per cent moisture, is cut by machine into small pieces and packed tightly into silos. Since this tight packing virtually excludes air, organisms such as yeasts and molds do not find conditions suitable for their growth and lactic acid bacteria grow preferentially to produce up to 1 per cent acid, which preserves the corn much as it does the cabbage in sauerkraut. No special techniques or cultures of microorganisms are employed to assure the growth of only the lactic acid bacteria. Although the corn plant carries on its leaves and stalks thousands of yeasts and molds as well as lactic and other bacteria, under the non-aerobic conditions which prevail in the silo only those organisms which can grow in the absence of oxygen survive.

Mold Fermentations.—Molds of the type that grow on stale bread, when moisture conditions are right, can produce substances of great value to man. Citric acid which gives lemons their sour taste is used in great quantity in the manufacture of soft drinks. Formerly all this citric acid was obtained from lemons. In 1917, however, the entire picture was changed when it was discovered that a mold, *Aspergillus niger* (a common black mold found on bread), could produce large quantities of citric acid when grown on glucose or sucrose solutions. Now over 90 per cent of the citric acid used in industry is made by mold fermentation.

Molds made their greatest contribution to the welfare of mankind after Sir Alexander Fleming discovered in 1929 that they secreted a principle which had a toxic effect on bacteria. Since the factor was first obtained

from *Penicillium notatum*, Fleming termed the principle "penicillin." During the past twenty years other species of molds and even bacteria were found to produce these so-called "antibiotic" substances and now such materials as streptomycin, actinomycin, polymyxin, aureomycin, choloromycetin, and many others are used by the medical profession to prevent or combat growth of pathogenic bacteria in the human body. The list of antibiotics today must number well over one hundred, each having its own specific effect on certain bacteria or other organisms. The manufacture of these chemical substances is still based on isolation from products of mold fermentation since the chemical structures of these compounds are so complex that the organic

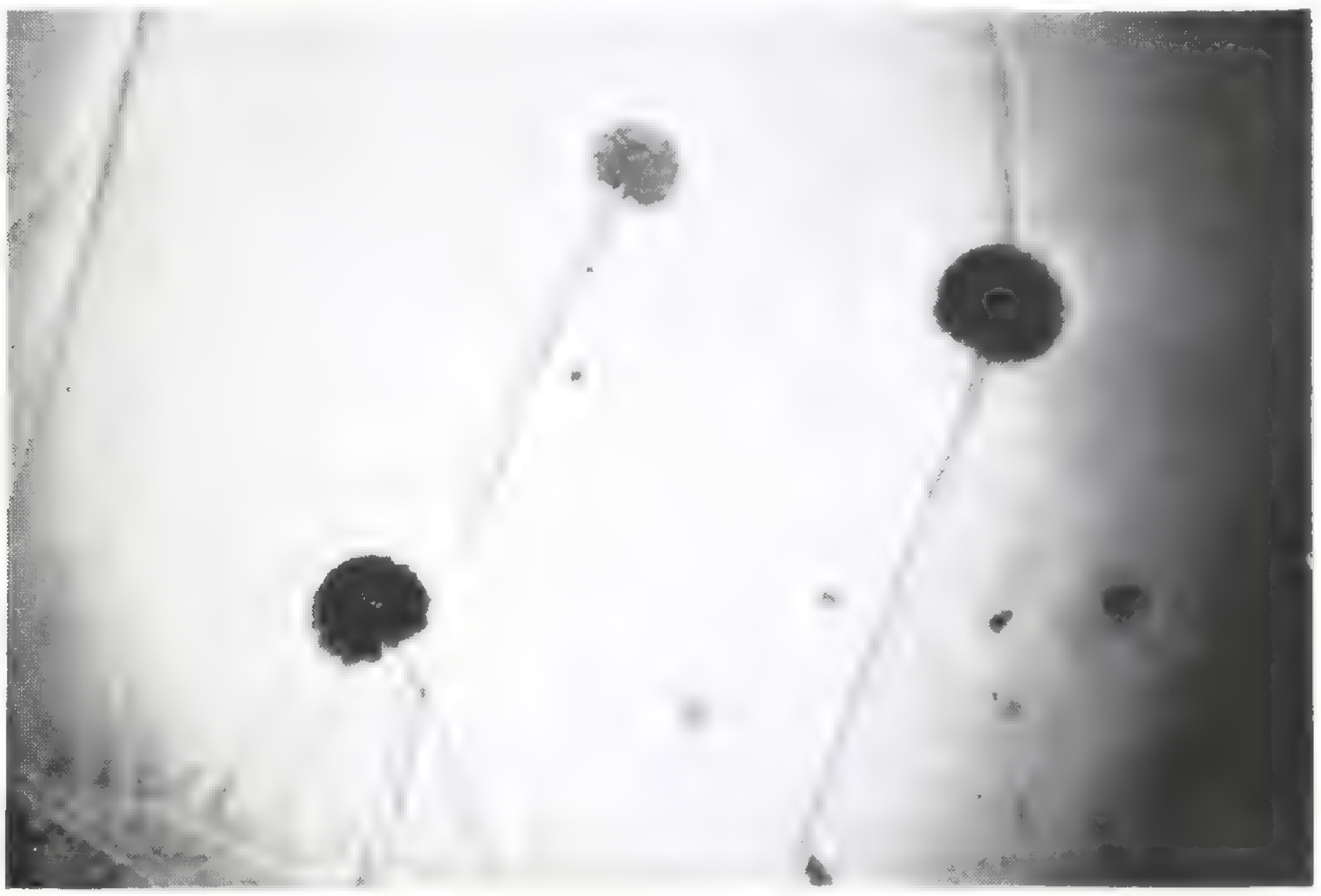

Fig. 3. *Aspergillus niger*, the mold used in the manufacture of citric acid. Magnified 150 times.

chemist has not been able to effect a practical synthesis of most of them. Before leaving the subject of antibiotics, the commercial production of one of the newest B-vitamins from the by-products of streptomycin manufacture should be mentioned. The "Animal Protein Factor," which in many ways is related to the "Anti-pernicious Anemia Factor (Vitamin B_{12})" for human beings, is at present being recovered from streptomycin residues and sold as a feed supplement. It is suspected that this new and important vitamin is produced by many of the molds which are used in the manufacture of other antibiotics, and it may be that manufacturers of antibiotics will soon be recovering vitamin B_{12} from their residues.

Miscellaneous Fermentations.—The above by no means exhausts the application of microbiology to industry. Coffee and tea undergo fermentation before they are ready for the market. In the manufacture of leather, bac-

terial enzymes function in facilitating the dehairing operation. Cellulose-fermenting bacteria make it possible for ruminants such as the cow and sheep to subsist on grass and other cellulose-containing plants, and these bacteria by cellulose decomposition also produce methane, a constituent of the inflammable gas which arises from marshes and sewer sludges. There has even been some attempt made to put these cellulose-fermenting bacteria to work on cellulose waste products, such as sawdust, and collect the resulting gases as sources of fuel.

From the foregoing it is evident that these minute microscopic plant forms, known to the bacteriologist as bacteria, yeasts, or molds, have contributed and are continuing to contribute to human welfare. On the other side of the picture there are also the pathogenic or disease-producing microorganisms which continue to plague mankind and which have even been investigated as agents of bacterial warfare. It is hoped that microorganisms will continue to make their major contributions by fermenting sugars and producing useful by-products rather than be sprayed from aeroplanes or thrown into public water reservoirs in a new type of warfare.

WONDER DRUGS

SIDNEY RODENBERG AND MAS YAMADA

If you go to your doctor today the chances are fifty out of a hundred that you will receive an injection of a "wonder drug" or a prescription for a "wonder drug" in the form of tablets, candy, or gum. Furthermore, the chances are ninety-nine in a hundred that the drug will be penicillin. Probably every reader of this article will or already has received treatment with penicillin. There is hardly a family in the United States that has not benefited from it or other wonder drugs.

Wonder drugs are substances which are isolated from biological material and which have a destructive effect on bacteria and other microorganisms. It is for this reason that the drugs are called "antibiotics" (meaning "against life"). It was about June of 1943, when the shortcomings of the sulfa drugs were first being realized, that penicillin became a lively topic for discussion. In the six years that have followed, its success has been nothing short of phenomenal. It has been responsible for saving millions of human lives; it has become a multi-million dollar business; it has spurred vast reappraisal of the lower plants, the fungi, engaging many workers in investigation of the intricacies and source of the antibiotics.

The deficiencies of penicillin were recognized while it was still a research problem. Penicillin wasn't a cure-all. A useful technique for observing bacteria microscopically is to stain the organisms with various dyes. One of the most useful is the Gram stain, which separates all bacteria into two

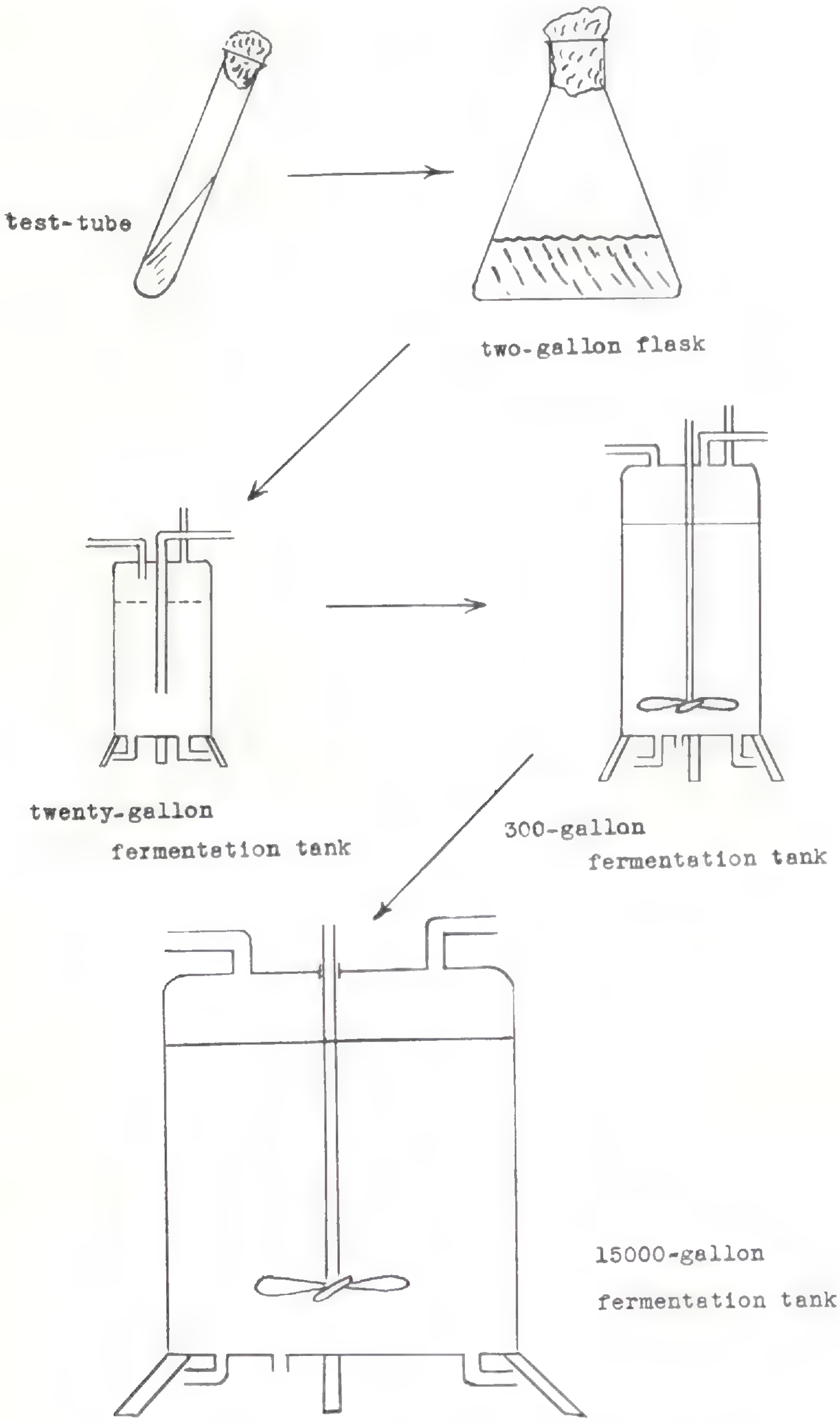

Fig. 1. Diagram of the build-up process in antibiotic production.

classes, Gram-positive or Gram-negative, depending on the color of the organism after staining. It was found that penicillin was destructive to most Gram-positive organisms, but left the majority of the Gram-negative ones unharmed. Still, the usefulness of the drug was unquestionable, since among the diseases caused by the Gram-positive organisms are tetanus, diphtheria, pneumonia, scarlet fever, blood-poisoning, and bacterial infection of the heart. A few Gram-negative organisms are also destroyed by penicillin, particularly those causing meningitis and gonorrhea. Certainly not to be overlooked are the wonderful results of the drug when used to combat the organisms which cause syphilis and trench-mouth.

Three problems became apparent from initial research: first, how did the drug act on the bacteria?; second, how could enough penicillin be produced to meet the need?; and third, could additional antibiotics be found to eventually treat all infectious diseases? Unfortunately, little has been discovered concerning the action of the drug, but the other problems have been investigated with a greater degree of success.

Production of penicillin on a large scale required application of a fairly new field of science,—that of biological engineering. The problem, of course, was to grow the penicillin-yielding fungi in large quantities and then to extract and purify the active principle. In the preliminary investigations, all penicillin had been produced in the laboratory in small tubes and flasks. It appeared that large fermenting-tanks instead of small flasks might be the answer to increased production, as is the case with most other industrial processes utilizing microorganisms. But before this could be realized many difficulties had to be surmounted. There were above all the problems of maintaining proper growth conditions—including the need for constantly available and suitable food material and sterility in all phases of manufacture. Emerging from the experimentation of several years, efficient production technique has become standard. Because of this penicillin is no longer a luxury but a drug which is cheap enough to be available to every one.

Present-day antibiotic organisms are grown in 15,000-gallon tanks or fermenters. To grow a goodly amount in a reasonable length of time it is requisite to use approximately 1,250 gallons of solution containing thriving antibiotic organisms as a "starter" or inoculum for the large tank. This starter solution is prepared in a number of smaller fermentation tanks, all of which are "seeded" from selected colonies grown in test-tubes in the laboratory. The nutrient broth provided for their growth consists of a source of carbohydrate, usually lactose, and a source of auxiliary growth material, a proteinaceous by-product of the starch industry, "corn steep water." The build up process is shown diagrammatically in fig. 1, and actual fermentation

Fig. 2. Intermediate 300-gallon tank in the build-up process of antibiotics.—Photo from Abbott Laboratories.

Fig. 3. View of the top portion of 15,000-gallon fermenters used in the final stages of antibiotic production.—Photo from Merck & Co., Inc.

Fig. 4. Mice being inoculated with a solution of penicillin to determine the toxicity of the drug.—Photo from Merck & Co., Inc.

tanks of different sizes in figs. 2 and 3. Delivery of inoculum from one tank to the next, additions of food material, removal of waste products, and the regulation of temperature (between 68° and 84° F.) during fermentation are controlled from an ingenious master panel which is able to "know" electronically how the fermentation is progressing. Sterilization of all equipment is accomplished before start of the fermentation by passing live steam through every tank and pipe line.

Addition of air to the tanks is necessary for growth of the organism. Numerous air compressors are thus employed to deliver 300 cubic feet of air per minute to each of the large tanks. In 24 hours a large fermentation tank will receive as much air as would be contained in 200 average living-rooms. This air is passed through numerous filters before entering the fermentation tanks, to assure its sterility. To be certain of a uniform product the growth medium must be agitated constantly. This is accomplished by a long shaft fitted with three propellor-like blades which rotate at the bottom of the tanks. The engineering problems involved in construction of these mechanisms were dealt with in record time, with the result that penicillin became available for limited use during the war, and was on the physician's list for treatment of his patients soon thereafter.

Additional problems existed, however, that had to be ironed out by the chemists and bacteriologists. The fermentation or growth of the micro-organisms lasts for only two or three days, at the end of which time the active principle must be removed. A method worked out for such separation involves filtering off the growth, extracting the solution containing the penicillin with a solvent and then removing this solvent in huge vacuum dryers. Vacuum dryers are used rather than ovens, for high temperatures will destroy the drug. The filtered residues which remain after such separation serve as a vitamin-rich livestock feed.

Tests are run on the extracted antibiotic to ascertain its toxicity, if any, (for this mice are used—see fig. 4), and to determine its effectiveness in destruction of bacteria (fig. 5). Testing of this kind is a major consideration in the production of any antibiotic. The Merck and Co. Inc. plant at Rahway,

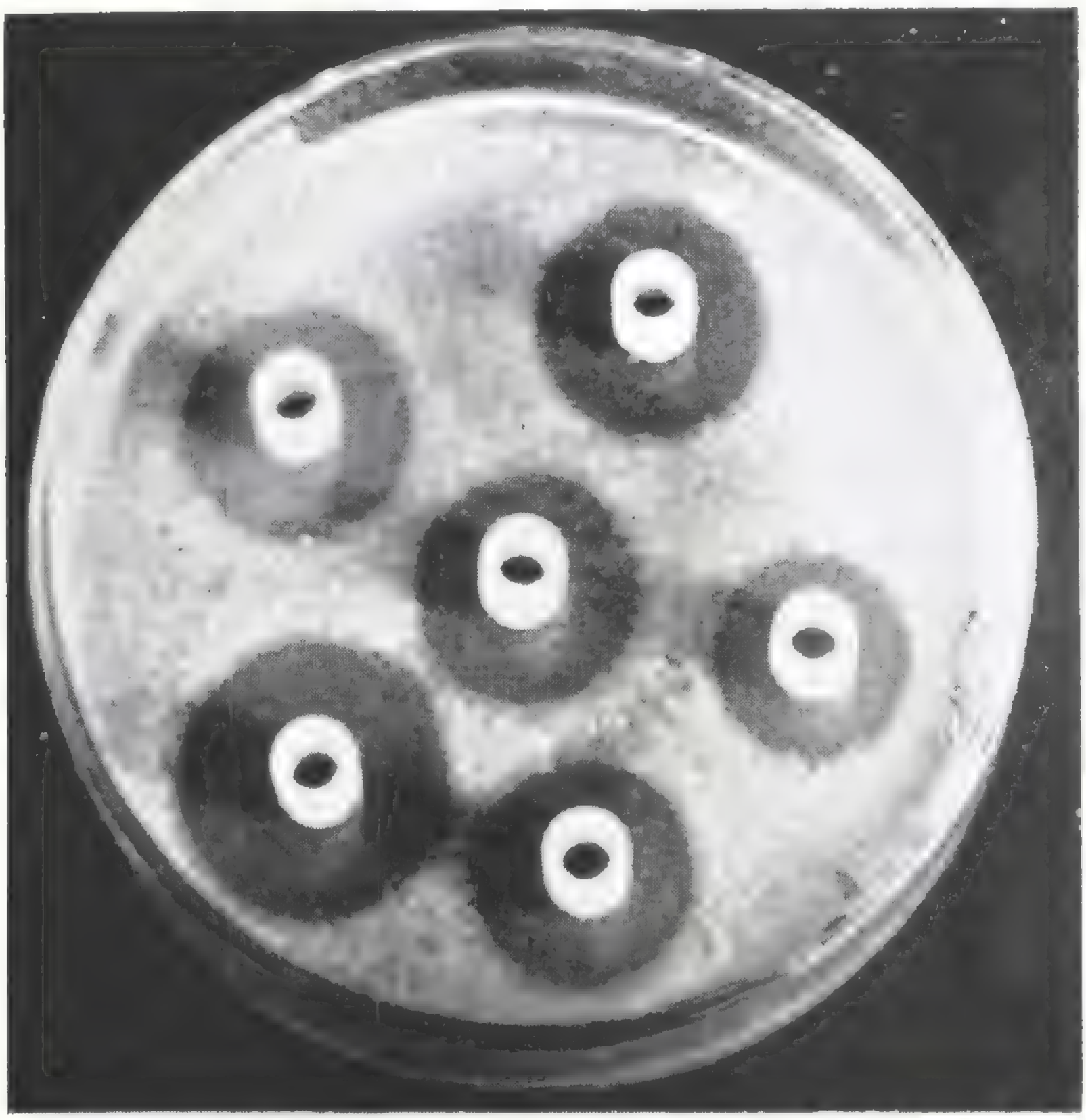

Fig. 5. Culture dish method of testing the effectiveness of penicillin in destroying living organisms. The dense whitish area shows growth of a bacterium, *Staphylococcus aureus.* The hollow white cylinders are placed above the growing Staphylococcus colonies and are filled with standard-strength penicillin solution. As the solution spreads out from under the cylinder, it prevents growth of the microorganisms, as indicated by the clear blackened region surrounding each cylinder. Measurement of the area of the clear region indicates the relative effectiveness of the particular penicillin solution in destruction of bacteria.—Photo from *Therapeutic Notes*, March, 1944, Parke, Davis & Co.

N. J., runs 2,000 potency tests daily on just a single antibiotic. The tested preparation is bottled and its stability determined to enable the pharmacist to know how long his supply of penicillin will be effective. The product is then ready for distribution.

So far nothing has been said concerning what penicillin is, or how it was discovered. In popular terms, penicillin is spoken of as a product of a "mold" or "fungus" as this type of lower plant is called. But such definition is very inexact. The name of the drug is penicillin, and the name of the plant from which it comes is Penicillium. In common usage the word "mold" generally refers to some unidentifiable fuzzy growth ordinarily a nuisance. Now although Penicillium is at times a nuisance to the fruit industry, the generalization is neither applicable nor fair. Penicillium is one of the large group of lower plants, the fungi, which have a great deal of utility in the realm of biology as beneficial decay and industrial organisms. Penicillium (meaning brush-like) is so named because seen microscopically it resembles many small brushes (see cover illustration). To the naked eye it appears as a thick, flat, velvety mat. It is commonly found on fruits, in Roquefort cheese, and its reproductive cells are everywhere in the air. It is one of the most common causes of fruit disease and decay, and has probably been seen by every housewife as the greenish growth on deteriorating oranges. As a matter of fact, the most productive penicillin strain of Penicillium was found on a cantaloupe.

The discovery of penicillin as an antibiotic was made in 1929 by Sir Alexander Fleming, at St. Mary's Hospital in London. It came by way of a fortunate laboratory accident in which cultures studied by Fleming were accidentally contaminated when exposed to air. The contaminating fungus had the effect of destroying other microorganisms growing on the culture plates. But this was nothing new. Many bacteriologists had observed such a phenomenon, and Louis Pasteur had written of such bacterial behavior as early as 1877. It was Dr. Fleming, however, who made the most detailed observations and identified the green growth as *Penicillium notatum*. He made numerous tests and even suggested that the material might be used as a salve for skin irritations. When several cases treated this way were without striking results, it was decided that the older routine drugs were more effective. Then in 1940 a group of men at Oxford University, under the leadership of Sir Howard Florey, published the results of intensive studies on the properties of penicillin, the medicinally active portion of the fungus Penicillium. It was the work of this group which established penicillin as a "wonder drug."

Research on penicillin continued, coupled now with an intensive search

for other wonder drugs. A set of requisites for a good antibiotic was established, which included such items as:

1. The drug must be lethal to specified bacteria.
2. The drug must not be injurious to the patient,—i.e., it should not be toxic.
3. The drug must be effective when placed in body fluids such as blood or spinal fluid.
4. The drug should not be destroyed by the normal activity of the body.
5. The drug should be stable with respect to time and temperature.
6. The drug should not be subject to a too rapid excretion from the body by the kidneys.
7. The drug should be of such nature that bacteria will not become resistant to it.

Few antibiotics can satisfy all these requirements, but with these goals in mind many new substances were tested for their antibiotic properties. The discovery of streptomycin by Dr. Selman A. Waksman at Rutgers University has been the most fruitful find next to that of penicillin. Waksman extracted the drug from a plant, *Streptomyces griseus*, which is even lower in the plant kingdom than Penicillium. Its importance stems mainly from its activity against tuberculosis, although it also attacks many Gram-negative organisms against which penicillin is ineffectual. The methods of production of streptomycin are identical with those for penicillin, with the exception of the final extraction step. Here, streptomycin is adsorbed on activated charcoal and is removed by means of an alcohol-acid washing.

Other antibiotics which have proven useful are aureomycin and chloromycetin, which have much in common. Both were isolated from plants very similar to Streptomyces, and both have shown themselves to be active against a number of bacteria as well as a heretofore deadly "germ," the rickettsia. Diseases combatted with these drugs include Rocky Mountain spotted fever, typhus fever, parrot fever, and various types of bacterial dysentery.

The success of past investigations is stimulating even greater numbers of workers to the search for useful antibiotics. Research is now progressing along two distinct lines: first, the determination of the mode of action of the drugs, and second, the securing of a complete set of drugs so that every infectious disease can be effectively treated. Although a wealth of knowledge has been accumulated in the many fields concerned with antibiotics, the greatest praise must be given to Sir Howard Florey and his group at Oxford University. It was the basic investigation by this group that set the stage for the use of penicillin, and ushered in the era of antibiotics.

NOTES ABOUT LOWER PLANTS

ROBERT W. SCHERY

No sooner does one go beyond the confines of the city with its winter pollution of smoke than lichens are encountered. These frilled "doilies" or "splotches of paint" on rock and tree are an unique combination of alga (the simplest of green plants, usually aquatic) and fungus (familiar as molds and mushrooms). Both partners benefit by the relationship—the fungus affording shelter for the alga and the alga making food with its green pigment for the use of both. But these primitive beings of the plant world are very slow growing. Ethel H. Hausman recently measured the annual increase in size of a number of lichens, and found it to average less than one millimeter a year (about $\frac{1}{25}$ of an inch). Clearly, then, if this rate of growth is constant, as it seems to be, some of the lichen colonies must be of great age, for many measure inches or even feet across. Parmelia lichen rosettes in the Alps have been "guestimated" as having initiated growth 10,000 years ago. This is more than the age of the oldest tree known—some of the Sequoias of California being 4,000–5,000 years old. Of course, this does not mean that every cell of the original lichen is still alive, for the center of the rosette may have perished and decayed and formed the physical basis for growth of higher forms of plant life such as mosses. This behavior is one of the valuable features of lichens, the first colonizers of the bare rocks and inclement mountain tops, since these hardy "plants" build up from the raw materials of rock, rain, dust, sun, and their own demise the thin soil that eventually may support other plant life and even, ultimately, agriculture. It is astounding to realize that deep in the Antarctic, where no "normal" plant can be seen, minute lichens "burrow" in the rocks and grow only during the few sunny weeks of Antarctic summer when temperatures become sufficiently warm to allow these pioneers to resume their incredibly slow growth.

The feature articles of this month's BULLETIN deal with some of the lower plants with which many readers may not be overly familiar. Yet every one recognizes a related group—the mushrooms and toadstools. Strange as it may seem, the organism responsible for penicillin is not greatly different from a mushroom in its general mode of existence—that is, in absorption of food from its inert surroundings, its occasional sexual reproduction, and the physical make-up of the many living filaments that collectively constitute both mold and mushroom.

The minute spores of mushrooms and other fungi, including, of course, Penicillium, yeast, bacteria, and hosts of other lower plants, are everywhere about us, wafted by the slightest breeze. Proof of this is easily obtained by letting a piece of moist bread or other food remain exposed to the air for even a few minutes. If the food is then maintained warm, in no time at all a fungal growth will develop. Much of this growth is hidden from view, just as the main mass of mushroom growth spreads as an invisible cob-webby network through the soil, gathering food and moisture for production of the conspicuous stalked cap. It is common knowledge that microorganisms causing spoilage will not grow well on heavily salted meat or strongly sugared jelly. This is not because spores do not alight there, but because they are killed, if they start to grow, by the high salt or sugar concentration. The effect is the same as if the substance were kept thoroughly dry, and of course no microorganism can thrive without ample moisture. Mushrooms, for example, usually appear in nature during the rainy season.

Some fungi derive their food in the fashion mentioned above; others get nourishment from decaying wood or from decomposing waste. And, of course, the disease-producing kinds actually attack living beings or other organisms. The remarkable thing about the great multitude of fungal species is that they must depend, directly or indirectly, upon green plants to put together the organic molecules that give them nourishment. Only the green plants can synthesize food from air, water, and sunlight. When one thinks about it it is apparent that every living thing "eats" green plants or things that somewhere down the line are the beneficiaries of nourishment from green plants.

The above-ground portion of a mushroom—that commonly eaten—is a reproductive structure. In most mushrooms ridges of tissue on the under-surface of the cap radiate out as spokes of a wheel. These are the gills. Completely covering the gills, but individually invisible to the naked eye, occur thousands upon thousands of spores, each able to grow into a new mushroom plant if happening to encounter a suitable environment. If one removes a mature cap and places it on a sheet of white paper the many spores that will drop leave a perfect outline of the cap and its gills. In determining kinds of mushrooms it is often necessary to decide spore color by this means.

Botanically there is no sound distinction between mushrooms and toadstools, although in popular lingo the latter refer to poisonous types. Fortunately poisonous mushrooms are rather uncommon. There is no easy and

infallible way to tell a poisonous mushroom from an innocuous one. To be certain of the edibleness of any mushroom one must be able to recognize the species in question—a matter requiring considerable experience. A notoriously poisonous group are the Amanitas, characterized by having a swollen cup just below ground and a loose ring of tissue on the stalk just below the cap or spreading top.

The fungi are of very great and real practical importance, as industrial uses, disease, and decay attest. It may not be realized that they also play an outstanding role in the drama of theoretical research. For example, the frontiers of biology are progressing rapidly at the moment through investigations on the heredity and physical organization of a mold known as Neurospora. The simpler plants often have many advantages over the more complex plants and higher animals in working out the fundamentals of heredity and life processes, since the very complexity of the latter may obscure experimental results.

Microorganisms often have unusual and diverse influence upon man and his world. Did you know, for example, that the Red Sea is so named because of a reddish unicellular plant growing there; that the travertine terraces in Yellowstone Park are deposited by similar microorganisms, frequently not only able to live in the boiling waters of some of the hot springs but unable to live elsewhere; that many members of the bean family will not grow well unless the proper microorganism "parasitizes" the roots; that the roots of many familiar higher plants, such as species of orchids, grow in mutually helpful association with certain fungi (mycorrhizae)?

NOTES

Mr. Louis G. Brenner, of the Arboretum staff, has been elected chairman of the botany committee of the St. Louis Audubon Society.

A party of sixty women of the Clark County Home Bureau, Marshall, Illinois, visited the Garden on November 10.

Recent visitors to the Garden include Mr. Charles B. Harding, President of the Board of Trustees of the New York Botanical Garden; Dr. Charles E. DeVol, of Marion College, Marion, Ind.; Dr. Harry J. Fuller, of the University of Illinois, Urbana; Dr. E. R. Spencer, Soil Specialist, of Lebanon, Ill.; Mr. Bernard Lowy, of the botany department, Iowa State University, Iowa City; Dr. T. G. Yuncker, of De Pauw University, Greencastle, Ind.

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SOME FACTS ABOUT THE GARDEN

The Missouri Botanical Garden was opened to the public by Mr. Henry Shaw about 1860. From that date until his death in 1889 it was maintained under his personal direction. Although popularly known as "Shaw's Garden" the name Missouri Botanical Garden was chosen by Mr. Shaw and he definitely indicated that he wished it called by that name. The Garden passed at his death into the hands of a Board of Trustees, designated in Mr. Shaw's will, and the Board so constituted, exclusive of certain ex-officio members, is self-perpetuating. By a further provision of the will the immediate direction of the Garden is vested in a Director, appointed by the Board. The Garden receives no support from city or state but is maintained almost exclusively from the estate left by Henry Shaw. Since 1939 many Garden Clubs and interested individuals have contributed to a "Friends of the Garden Fund" which is used in developing the new Arboretum, located at Gray Summit, Mo. The Arboretum (1) serves as a source of plants, trees and shrubs for the city Garden; (2) affords areas for gradually establishing a pinetum, a wild-flower reservation and various other features on a scale not possible in the city; (3) provides greenhouses for some 40,000 orchid plants.

The city Garden comprises 75 acres, where about 12,000 species of plants are grown, both out of doors and under glass. It is open every day in the year except New Year's Day and Christmas; week days, 8:00 a. m. until 7:00 p. m.; Sundays, 10:00 a. m. until 7:00 p. m. The greenhouses are closed every day at 5:00 p. m.

The main entrance to the Garden is at Tower Grove and Flora Place, on the Sarah bus line (No. 42). The Tower Grove bus (No. 21), direct from downtown, passes within three blocks of the main entrance.

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